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ALL INDIA VILLAGE INDUSTRIES ASSOCIATION

K.V.33

APER MAKING

(AS A COTTAGE INDUSTRY)

413

BY

K. B. JOSHI

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Rs. 4/-

The All-India Village Industries Association

PAPER MAKING

(AS A COTTAGE INDUSTRY)

By

K. B. JOSHI

Consulting Chemist, A. I. V. I. A. Wardha

with

APPENDIX E

"Migration of Paper from China to India"
A. D. 105 TO 1500

By

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Curator, Bhandarkar Oriental Research Institute, Poona

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PUBLISHER'S NOTE TO FOURTH EDITION

Some ten years ago, few had heard about the indigenous paper industry of India and fewer still were interested in its development. Interest in the revival of the hand-made paper industry may be said to have been awakened with the establishment of the All India Village Industries Association in 1934. The reorganization of the industry on sound lines formed part of the programme drawn up by the Association; and among its first activities was the opening of a paper production and research centre at Wardha. The author of this volume, Sjt. K. B. Joshi, was associated with this effort almost from its very early beginnings. Sjt. Joshi's researches and investigations have not ended; they are now carried on mainly at Poona at the Hand-made Paper Research Centre conducted by the All-India Village Industries Association, with the aid of a grant from the Government of Bombay.

That this volume has to be published in its fourth edition bespeaks the popularity of the subject and conveys an appreciation of the manner in which it has been dealt with. In this edition, an attempt has been made to bring all the information upto date and to refer to the latest developments of the industry. It is hoped that this revised edition will be found particularly helpful now, in view of the great demand that has arisen for hand-made paper and the inquiries that are being made, from all over India, for the starting of paper production plants. The volume is likely to prove particularly useful, to those interesting themselves in the industry, from the practical point of view. It will also give to the student of industrial developments an idea of the improvements that have taken place in the industry. As an out-come of the spread of knowledge and information about the technique of the industry it is to be hoped that it will receive considerable stimulus in the years to come and provide increasing employment all over the country.

BOMBAY,
27th November 1943

Vaikunth L. Mehta

PREFACE TO THE FOURTH EDITION

As a result of the use of power in pulp-making, the village paper industry has entered a new phase of its life. The small machines have been copied at many places and more enquiries about them are being received by the author from all parts of India. Had it not been for the abnormally high prices still more factories would have been started. In view of the new demands of a technical nature this volume has been considerably revised and enlarged with new information on the subject. Whatever experimental work and data in regard to the conversion of various fibres and varieties of paper have been collected, are incorporated into this edition. They are still being verified.

Apart from the existing improvements in the old technique of the processes and implements, for the production of faultless high-grade paper as understood today, still further improvements are necessary. They are the introduction of a rag-chopper and duster, a sand trap, a pulp strainer, English style paper-lifting moulds with water marks, the use of felts of appropriate texture especially for the artist's drawing paper, a heavy roll calender with suitable compound lever and weight arrangements, etc. Owing to lack of funds the author could not go further than satisfying himself with small models of some of them.

During the course of investigation on sunn-hemp and linseed fibre, it has been found that next to cotton rags, they would form better substitutes for linen rags, the use of which gives the peculiar characteristics to the foreign hand-made paper. Linseed fibre must be obtained in a clean form. After several trials it is found that rag and sunn-hemp pulps mixed in equal proportions yield an excellent drawing paper of artist's requirements, while the drawing paper made from cotton rags alone is not so satisfactory for that purpose.

For the standardization of the processes and products a well-equipped laboratory with paper-testing appliances is quite

essential in the absence of which the work remains vague. But here too the author is considerably handicapped.

Like other arts and crafts, paper-making was once conducted on the basis of an organized guild. But the history of paper-making in India has not received the serious attention, it deserves at the hands of the scholars in Indology. The author had this in view since the time, he devoted himself to this village industry. Such studies have national importance from the point of view of culture, history, economics and sociology. This subject being outside his sphere, the author approached Sjt. P. K. Gode M.A. of the Bhandarkar Oriental Research Institute, Poona, to prepare a note on the subject with the present available data. In response to this Sjt. Gode kindly consented to undertake such a task and his note appears in this edition under the title of "Migration of Paper from China to India from the 1st to the 15th century A. D." in Appendix E. The subject has still more scope for investigation. Much useful history can be found out from ancient MSS, sanads and court documents from the settlements of the kagzis known as kagzipuras at different places during the Mogul period of Indian history as the Moguls were great patrons of this and allied industries.

The shortage of paper due to war has aroused the interest of the school-going population in this subject, and it is likely that the art of paper-making may be introduced in schools as a part of school activities. In view of this the requirements of a school paper-making unit, together with a brief description of the paper—making processes, have been added to this edition in *Appendix D.*

Finally, my thanks are due to Sjt. P. K. Gode, Curator, B. O. R. Institute, Poona, for the troubles he took in preparing the note mentioned earlier.

POONA,
Dated 2nd October 1943

K. B. Joshi

PUBLISHER'S NOTE TO THE THIRD EDITION

The one new departure in the policy of the A. I. V. I. A. indicated in this book is the use of power in pulp-making which introduces the digestor and the Hollander beater.

The Association has been struggling to keep the equipment needed within the reach of cottage workers on the one hand, and to devise suitable means of producing the best of papers by using original fibrous materials available to villagers on the other. After several years of experiments it has come to the conclusion that unless we are content to restrict ourselves to making paper out of waste paper, straw and such other raw materials only, which easily yeild to treatment by instruments within the reach of villagers, it will be necessary to produce pulp from rags, jute and other hard fibres by using bullock, steam or electric power at recognised centres which will be subject to conditions of work excluding chances of exploitation, and to supply such pulp to village vatmen to lift paper at a cost which will make hand-made paper popular.

This power pulp making unit may require several thousands of rupees as capital as will be seen in the estimate for such a unit given in Appendix E of this book, (*unit no 2 page 164 in the new edition*) Such finances are much beyond the reach of villagers and cottage workers and hence they can be organised only through co-operative effort or by institutions which have the promotion of village industries at heart.

We trust these methods will be utilized with extreme care and under well controlled conditions so as not to frustrate the purpose with which the Association places this book before the public.

MAGANVADI, WARDHA,
20th June, 1942

J. C. Kumarappa

PREFACE TO THE FIRST EDITION

The booklet attempts to describe the processes and appliances needed for cottage paper making, in a manner as would be easily understood by an average man who has little or no theoretical or chemical knowledge.

It is requested that those who take to cottage paper making should communicate to the author their experiences and difficulties, or any errors that may have crept into this book, so that the same may be investigated, errors removed and useful information incorporated into a bigger treatise on village paper industry which it is hoped to publish at a later date with full details, both chemical and mechanical, of new developments and improvements effected, such as a dhenki worked either by bullocks or by water turbine, a stone beater, a drum washer, a modification of the Hollander beating machine to suit cottage conditions, all of which are under trial at the A. I. V. I. A. at Wardha at present. The processes and machinery described in this booklet may be modified as required.

The author is grateful to Sjt. Manilal Lallubhai and his son Mr. Mayabhai Teli, the proprietors of the Indian Cotton Oil Mill, Navsari, for affording facilities for him to work on cottage paper making at the headquarters of the A. I. V. I. A. Wardha.

The drawings in this booklet are made by Mr. S. B. Sathe, student of the School of Architecture, J. J. School of Art.

BOMBAY,
5th February, 1938

K. B. Joshi

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HINDI OR URDU TERMINOLOGY OF SOME OF THE WORDS USED IN PAPER MAKING

Brush	कुंचा, बोरा
Cylindrical piece of wood (Pestel)	खलतम्
Flint, Quartz or agate stone	गार
Hammer or beater or tooth of stamper	दांत
Heap of paper layers	भिद
Iron rim of the pestle	श्याम
Khadi dhoti or cloth	मोटक चदर
Lever of stamper	लकडी
Loose rectangular bars	छिचका
One who cuts the raw fibrous material	टोक्या
One who cuts or trims paper	वडाया
One who polishes the paper finally	घोटया पक्का, मोरखस
Opposite side of Zum	खापरी
Paper lifter or vatman	कागझी
Paper lifting frame	खांसी, रछ, संचा
Paper lifting mat	छपरी, मीर
Paper lifting vat	होज
Pasting the paper on wall for drying	दिवाल लगाना
Polishing board or burnisher	पट्टी
Polishing stone	घोटा
Pulp	मावा, रांघा, लुगद्दी
Pumice stone or porous stone	झामा, झाल्बा
Quire of paper	दस्ता
Raw fibrous paper-making material	सण, शण, टाट
Round wooden bars of the mat	घोराडे
Rubbing floor	ओटा, चबुत्रा
Sizing	कल्प
Slight fold given to the paper	झम्
Soap	सत्नून
Stamper	ढेकी, जग, जांडर, जंतूर
Stirring rod or bamboo	खेळणी तंडाळी
Trough	कुंडी

CHAPTER 1

INTRODUCTION

PRIOR to the introduction of paper as a writing material, various materials were used to write upon. Man being an intellectual being wanted to perpetuate his knowledge and events of his time for the benefit of his future generations. During the different periods from the earliest history of human civilization to the present day, various means were divised and used as writing materials. In the earliest stages when no other means were available, man committed to memory, his poetry, literature, philosophy etc., and thus the stock of his knowledge was carried from father to son or from the older to the younger generation. The important events of these periods were also narrated to future generations by traditions. We can trace the present day recital of the Vedas and other religious literature to this ancient mode of communicating the thoughts to posterity.

At a latter stage, events were celebrated by anniversaries as we have even to this day Krishna Jayanti or Christmus day or Id-e-milad etc.

With the acquisition of the art of writing or depicting the thought pictorially which owes to his faculty of imitation, man wrote upon such materials of bricks or erected pyramids, stupas or minars on which he inscribed important events or court decrees so that they might not to be lost by the ravages of time. Thus we are able to read the events of Asoka and other period from the pillars erected to perpetuate the events of the time. They are a living memory of the past history. With the advance of civilization and the acquisition of the knowledge of preparing metals, lead, copper, or bronze plates were used for writing upon.

At a still latter stage, papyrus and parchment were used in outside countries. The word "Paper" is derived from papyrus, a weed growing on the banks of the Nile. The weeds were stripped and while wet, were put horizontally and verti-

cally and pressed together to form a sheet which appeared like paper. Documents written on papyrus have been found out in Egypt and are as old as 3000 to 2000 B.C.

Parchment or tender skins of animals were also used by the Persians and the Greeks to write upon.

In the earlier periods of the Christian Era, palm leaves and the barks of trees were used to write upon in various countries in the East and also in Egypt. Before paper-making was introduced into India, Bhurj-patra, bark of the Bhurj tree found in Persia and the countries bordering the Himalayas and Tad-patra, leaves of the palm tree found in the South were largely used for writing MSS from which we are able to read our ancient lore. The leaves were prepared by cleaning and boiling in water and bleaching them in the sun. Tad-patra migrated from the South to the North and Bhurj-patra from the North to the South.

During Alexander's invasion of India one of his generals had observed that the Canarese used cloth coated with tamarind paste, as a writing material at that time.

At this period, a stage was ripe for the appearance of paper as it is known today, in that a web was prepared by placing the strips of papyrus horizontally and vertically and the processes of cleaning, boiling and bleaching were used in making the leaves of the palm suitable for writing purposes.

These were almost the same processes as are used for paper-making.

Paper as is known today was first made in China in A.D. 105. Before the general use of paper as a writing material the Chinese used silk or strips of bamboo or bark-cloth to write upon. The bark-cloth was prepared by stripping the inner bark from the mulberry plant and cleaning and pasting several barks together.

For sometimes the art of paper-making was kept a secret, but ultimately during their raids on China, the Arabs learnt it from the Chinese prisoners and established a paper factory at Samarkand at about the middle of 8th century towards the

close of which a factory was also established at Bagdad. From this place it was introduced into Egypt at about A.D. 900. Then at Morocco (A.D. 1100). The Moors introduced paper-making into Spain at about the middle of the 12th century. It then went to France at close of the 12th century.

Simultaneously paper-making was introduced by the Arabs into Italy towards the close of the 13th century. From Italy it spread to Germany. Ullman Stromer erected a famous paper factory at Nuremberg in 1336A.D. Paper was being made in England in 1494 by John Tate. In America paper-making was introduced in 1690 by William Ritten house.

Paper-making was introduced into Japan in about 7th century A.D. and this art is flourishing in that country even to this day.

It is not definitely known when paper-making was introduced into India. However, it is supposed that Mahmud of Gaznavi introduced it in the 10th century during his first invasion of India. If the Chinese are credited with the invention of paper, to the Muslims goes the credit of spreading it into Europe and India during their conquest of those countries. Along with the invasions by the Moghuls, the art spread into the different provinces of India. The history of paper-making and its spread in this country still remains in shrouded mystery although during the Moghul and the Peshwa period it flourished throughout the whole country, giving employment to thousands of people, men and women of all ages and children. The industry flourished most in the Punjab. It is reported that during Jahangir's time paper produced at Sialkote only was worth about Rs. 9 lacs. Paper was also produced at Multan, Rawalpindi, Jalalpur-pirwala, Delhi, Lahore and several other places. During the Sikh period about 1200 gaunders (dhenkis) were working in Sialkote alone. Each dhenki produced about 20 maunds of pulp and brought an annual income of about Rs. 120 to the owner (C. Gee's Monographs on Fibrous Manufactures of the Punjab). Later on, during the British period, paper-making was also introduced in the Jails of that province. In U. P. paper-making was practised at several places in Muthra, Kanoj, Agra, Kalpi,

Bareilly, Bijour, Budaon, Gazipur, Benares, Ajemgarh, Mirzapur, Shahajahanpur, Dehra-Dun, Shamly, Kael, Hathrus, Banda, Jaunpur, Kurra, Faizabad, Lucknow, Rahimbad, so also in several jails in that province.

In C. P., paper factories existed at Zainabad and Panchamnagar, Chanda, Akola, Buldana etc. In Madras paper was made at Chingalpet, Sidapet, Conjeverum, Vellore, Gudiathum, Lalapet, Palipur, Naraina-varum, Ramnad, Dindigul, Caroor, Tinnevelly and several other places. Paper was also made in some jails. In Mysore hand-made paper was made at Bangalore. In Bombay and Sind paper was made at Ahmedabad, Ankleshwar, several villages in Kaira, Surat, Thana, Mahad, Nasik, Erandol, Junnar, Poona, Satara, Wai, Karad, Shenay, Belgaum, Gokak, Kolhapur, Shahapur, Karachi, Hyderabad, Nasrapur and Kandiaro, Shikarpur, Larkhana, Rohri. The paper of Daulatabad (Deccan) was famous at one time.

It spread to Nepal from China through inter-communication between the two countries. The Nepalese and the Bhutias make paper out of young bamboos and barks of certain plants such as daphne cannabina and edgeworthia gardneri. The paper made from these is very strong, tough and durable. It is proof against ants, worms and rats. Nepal paper is famous for its strength and toughness. The sheets are as thin as the Oxford India proof paper. The industry is still being carried on in those parts.

The art of paper-making was carried out by the Muslim Kagzis under the patronage of the Moghul Emperors. They had their settlements which are still known as kagzipuras indicating that they were the centres for the production of paper in those days. They were situated on the important trade routes. The trade at that time was carried on pack animals by a community known as Vanzars. Owing to its strength sunn-hemp was used for gunny bags. The paper-makers chiefly used old gunny bag wastes which were no longer of any use to the Vanzars. The arrangements of the factories and the processes of paper-making were almost the

same everywhere, without any improvements in their methods since its introduction into India.

Upto the middle of the 19th century the paper requirements of India, besides being met locally were supplied by China. But afterwards her requirements were supplied by the British and other European manufactures, and during Sir Charles Wood's (Lord Halifax) time (as Secretary of State for India) all Government supplies were ordered to be bought from Great Britain. At the same time great discoveries in modern science, both mechanical and chemical, revolutionised the industry in foreign countries. The policy of the Government of buying their supplies from abroad and the import of cheap machine-made goods affected adversely the Indian paper manufactures in villages. If one visits the old paper producing centres, one realises how well they must have flourished at one time and what humming centres of activity were the places which today are in ruins.

Had it not been for the sawkar who genaraly uses Indian hand-made paper for his account books, the indigenous paper industry would have disappeared altogether. The Indian sawkar has been instrumental in keeping this industry alive here and there. For some time during the last quarter of the last century the Government had introduced paper-making in jails in some provinces but ultimately it was abandoned.

Old paper-making processes

The raw material chiefly used for paper-making was old gunny bags made of sunn-hemp and old paper chiefly as account books from the sawkars. In the North, old fishing nets, rags and other fibres were also used. The raw material was known by the general name tat or. (तात)

(1) The tat was cut into small pieces one inch long with an hatchet by men, known as Tokyas (cutters). The fibres from the cut tat were loosened by thrashing it with a mallet and were shaken to remove dust.

(2) This was then washed in a river or tank by two men standing opposite each other with a piece of cloth tied to their waists. The material was put into the chaddar and worked to

and fro in the water with their hands. This freed the material from the adhering dirt.

(3) The material was then worked under the dhenki to separate the fibres and again washed in the river. This beating was known as Kutai (कुतायी) washing being known as (धुलायी)

(4) It was then mixed on a stone floor (ओटा) with Sajjikhar and Chunam in the proportion : Tat-8 parts, Sajji-4 parts, Lime 1 part. (The proportions slightly varied from place to place) and kept in small heaps for several days for retting or fermentation on an open floor and exposed to the sun and air. This also bleached the pulp to some extent.

(5) The mass was then pounded under the dhenki several times till it was reduced to pulp.

If necessary the 4th and the 5th processes were repeated once or twice.

(6) After the pulp was made, it was sometimes mixed with plenty of water and beaten under the broad stamping beam of the dhenki without the teeth. This was known as Zabkai. This separated the fibres and at the same time hydrated them.

In the meanwhile if waste paper was to be mixed with the pulp from the tat, then it was torn to small pieces. These were then moistened with water and kept in heap over a clean ota for a fortnight at the end of which it was trodden under feet and rubbed over a rough floor till it was reduced to pulp. It was afterwards washed in the usual way. At some places pulps were made by simply rubbing without trampling.

Sometimes the waste paper was treated with about 5% sajji and kept for a week or so before it was trodden and rubbed.

Country soap was finally mixed with the pulp either from tat or waste paper (वही खाताकी रद्दी) in the proportion of 5 seers of soap to 3 maunds of the material. This was known as साबून कि जरीश.

The dhenki treatments were repeated several times. Similarly the pulps were washed several times in the river,

after each dhenki treatment. Occasionally the pulps at intermediate stages were exposed to sunlight for bleaching.

It took 15 days for 7 men. (6 men for pressing the dhenki and one for pushing the pulp under the pestle (खलत्तम्) to convert 3 maunds of tat into pulp. The pulp was now made into balls (गोले) and kept in heaps before it was used for sheet making).

(7) The golas when required were put into a small cylindrical reservoir (कुन्डी) which is close to the vat and mixed with water to have the consistency of gruel and trodden with feet so as to separate the lumps. This was transferred to the adjoining vat which was almost filled previously with water. It was then stirred with a stick (छेलणी) by a man on contract and left at rest over-night.

(8) Next day the kagzi or kagaj kadhya (vatman) begins to make sheets. The system of old vats and paper-lifting was as described elsewhere in this book (infra). Paper-lifting was based on contract for 240 sheets per day.

(9) The wet sheets were covered with a piece of cloth and then a board over which stones were placed over-night to squeeze out most of the water from them.

(10) The pressed sheets were next separated and stuckon the wall for drying by a brush (द्विवालबन्द or द्विवाल लगाना) by a man, द्विवाल लगानेवाला. This was done by young folks.

(11) The dried sheets were collected and cleaned with a piece of pumice stone or burnt tile (झामा, झाल्वा) by an old man or a woman, who was known as झाल्वा मारनेवाला who was on contract basis.

(12) Next operation was sizing (कल्प लगाना). The size was prepared by soaking wheat for 2 or 3 days and extracting the milk which was boiled with the required amount of water to which some alum and copper sulphate were added. The paste was applied by a brush or a piece of cloth. This was done mostly by women. The contract was on guddi basis, the cost of the wheat and fuel being borne by the owner.

13. When the sized sheets were dry they were polished on a burnisher with a polishing stone (घोटा). This was done by

young men or women. The contract basis was on a quire (दिस्ता).

(14) The next process was trimming the edges of the sheets into the proper sizes.

The sheets are then sorted into different grades, the first grade being faultless, others having some blemishes in the paper. The standard is a guddi or half ream of 240 sheets.

The working of the units was harmonious since every job was on contract basis; the wages varying according to the nature of the work.

The following extract on the expenditure of labour and material for paper-making by the old processes will be found interesting. It is taken from the monograph on paper-making in C. P. The details of the expenditure of manufacturing 10 guddies of paper in old days out of 3 maunds of tat were as under :—

		Rs.As.Ps.
1.	3 Maunds of tat + Rs. 1-8-0 per maund ...	4— 8—0
2.	Cutting charges at Re- 0—4—0 per maund...	0—12—0
3.	Wages of 7 men for dhenki for 15 days ...	15— 0—0
4.	Chuna 6 paseries ...	0— 8—0
5.	Sajjikhar 4 seers ...	0—12—0
6.	Sabu (soap) 5 paseries one paseri per rupee ...	5—0 —0
7.	Dhulai (washing) ...	0—8 —0
8.	Charges of paper-making for 10 guddies ...	5—0 —0
9.	Dewal chadhai ...	1—4 —0
10.	Kalap making (sizing) ...	5—0 —0
11.	Ghutai or polishing ...	10—0 —0
12.	Miscellaneous expenses for 10 guddies ...	1—12—0
	Total Cost of 10 guddies ...	Rs, 50— 0—0

One guddi was sold to the merchant for Rs. 10/-Thus the kagzi used to make cent percent profit. This was in the last quarter of the 19th century.

MODERN USES OF HAND-MADE PAPER.

Hand-made paper is made from choice raw materials. In England and other foreign countries fine grades of linen

and cotton rags are used for high class paper. Linen rags are not available in India in large quantities. Hence cotton rags, sunn-hemp wastes and to a certain extent linseed fibre, if it could be obtained clean, are most useful for such purposes.

The raw material does not receive any harsh chemical treatment in boiling and bleaching, so that the quality of the cellulose is not deteriorated. The beating is carefully regulated so as not to injure the fibre. Unlike the machine made paper, the fibres in the hand-made paper are well felted or matted together as the wet pulp on the mould receives shakes from all directions at the hands of the vatman. The sheet dries in its natural state as against the artificial means employed for drying machine-made paper. In modern practice hand-made paper is sized with glue or gelatine.

All these .produce special qualities in hand-made paper. It is used where strength, durability and endurance are required for which machine-made paper is not suitable. The uses to which hand-made paper is put are :—

Currency of Bank notes as they have to undergo considerable handling every day while in circulation. (2) Printing valuable books. (3) Ledger and account books— as the books are required to last long and stand rough and hard handling. (4) Filter paper for chemical analysis. (5) Drawing paper—since "grain and fine texure" together with strength and durability are required in such papers as are used by the artists and architects. In water colour painting the drawing paper is required to stand the stretch over the board ; so also paper must stand the colour washes at the hands of the artists. (6) Legal documents wills, share certificates, Sanads etc.. as the paper must stand hard wear and tear ; so also it must not deteriorate for a considerable time. Over and above, hand-made paper, being fine in texture and of artistic appearance besides the qualities mentioned earlier, is also used for (7) Photographic and picture mounts ; (8) Vellum papers, (9) Note paper and envelopes as high class stationery, wedding, Christmus and Divali greeting cards, (10) Fine etchings, engravings, (11) Presentation of addresses etc.

CHAPTER II

RAW MATERIALS

The chief raw material used in paper-making is of a fibrous nature. The useful component of such fibres for paper-making is cellulose. Cellulose is never found in a pure form in nature except in cotton—the seed hair of the cotton plant—where it is directly available for textile manufacture. Generally the fibre containing the cellulose is compounded together with cells to form the structure of almost all the vegetable kingdom, even like brick and lime to form a wall, the fibre comparing with the brick and the cell with the lime of the wall. The separation of the fibre from the plant body is generally done by retting or steeping in water for some time, or by some other mechanical means like beating, scraping etc. A typical example of obtaining the fibre by retting is the method followed in the case of sunn-hemp, alœ fibre and ambari. It is also obtained by other mechanical means as in the case of the barks of certain trees such as the palas or dhak or plantain tree. There is another class of materials from which fibres as ordinarily understood cannot be separated still they are useful for paper-making for instance bamboo, straw, grasses etc.

According to their botanical characteristics and the ease with which they are obtained, the vegetable fibres may be divided into four classes :—

(1) Seed hairs. Cotton obtained from all species of the cotton plant; Silk cotton from the red and white semul tree; Mudar cotton obtained from the rui or mudar plant.

The fibres of this class are obtained in their natural state after the spontaneous bursting of the fruit during the ripening process. They form a protective coating for the seed contained in the fruit during its growth. They require no other treatment except collecting, unlike the succeeding classes.

(2) Inner bark or bast fibres. Sunn-hemp, flax from linseed stalk, edible and wild bhendi, malachra

digitata ambari or Deccan hemp, roselle or lal-ambari, bark of the cotton stalk, mulberry, mudar, Nepal paper plant, rameta, gorakhamli, etc.

The fibres of this class are not readily available as in class (I) but require treatment such as retting or teasing and peeling off from the mother stem, to which they adhere by cellular and mucilaginous matter which is easily removed during the retting process. Some times the barks are removed without retting but even then they require some sort of cleaning to remove the outer woody (parenchymatous) portion, hence also they are termed inner barks.

(3) LEAF FIBRES. The fibres of this class are imbedded in the leaves of the plants *e.g.* Sisal hemp, Ananas, Marul, Kevda etc. The fibres from the leaves are obtained in the same manner as in the preceding class or by scraping the leaves.

(4) STEM FIBRES. Grasses, bamboo, bagasse, straws etc., come under this class. No fibre as ordinarily understood can be separated from these materials. However cellulose fibres useful for paper are obtainable from them.

The fibres of the first three groups are available for textile manufactures such as cloth, sacking, ropes, twine etc. while the fourth group is not useful for such purposes.

The textile manufacturer is mainly concerned with the long fibres or filaments while the paper manufacturer is concerned with the ultimate cellulose fibres only, hence materials falling under all these four groups can be utilized for paper-making. From this description it will also be observed that for paper-making, the fibres in the first three groups may be used in the form of industrial wastes instead of the new ones which have other important uses, for instance cotton wastes, rags, old worn out clothes, old gunny bags, etc. while bamboo, grasses etc. of the 4th group are mostly used in their fresh state.

India produces a large number of fibrous plants in such a variety that paper of every description and sort can be

manufactured here. In fact no other country is richer in its fibrous kingdom than India. The number of such plants is about 100 to 125 or even more. In spite of this it is said that India lacks paper materials excepting a few grasses and bamboos. This may be true when we take mass production on a factory scale into consideration. But for production on cottage basis the materials available in villages are more than ample and can be obtained at almost negligible cost. At present much of this vegetable wealth is neglected.

Apart from this, even village waste like tailors' cuttings, old, worn out clothes, ropes, baskets, mats or old used thatch grass and such other material altogether useless for other purposes can be used for paper-making. Even waste paper, book binders' and stationery makers' paper cuttings can be turned into paper. The waste of the textiles, of fibres and ropes can also be used.

Date palm leaves, cotton stalks, linseed stalks, bark from phalsi tree, old gunny bags, old bamboo baskets and mats, rags, rameta bark, plaintain fibre, munj grass and sunn-hemp have been converted into paper experimentally without any complicated machinery, but with simple appliances which can readily be made in villages.

The other auxiliary materials used in paper-making are:

(a) *alkalis and bleaching agents* used in pulp making;

(b) *starches, rosin, alum, gelatine or glue etc.* in paper, sizing;

(c) *colours* in paper dyeing.

They will be dealt with under their respective heads.

List of some of the paper-making fibrous plants grown within India

	Botanical Name	*Local Name*	*Parts Used*
1.	Abelmoschus Esculentus ...	Bhendi, Ran turai	Outer bark of the stem
2.	Adansonia Digitata ...	Gorakh amli	The inner bark
3.	Agave Americana and varieties ...	Ghaipat, kekti	The leaf fibre or wastes of manufactured articles, old ropes, etc.,
4.	Abutilon Indica ...	Chakrabhend, mudra, Tuthinar	Outer bark of the stems
5.	Ananas Sativa ...	Ananas, Anasapandu	Fibres of the leaves
6.	Antiaris Taxicaria and varieties ...	Valkal tree, chandkuda Karvat	Valkal or inner bark
7.	Bamboo ...	Bamboo, Vans, Bans	The culms, baskets, mats, old or new, etc.
8.	Boehmeria Nivea ...	China grass of rhea	Bark fibre
9.	Broussonetia Papyrifera ...	White mulberry, tut	Inner bark of the young branches
10.	Butia Frondosa and varieties ...	Dhak, Palas	Inner bark of the young branches
11.	Canabis Sativa or Canabis Indica ...	Hemp, ganja, bhang	Bast fibre of the plant
12.	Corchorus Capsularis and varieties	Jute of Bengal	Bast fibre, toe, gunny bags, jute threads and their wastes

13.	Careyas Arborea	Kumhia, Vakumbha pailaeputty, Dudhippi	Inner bark of the tree
14.	Crotalaria Juncea and varieties ...	Sunn hemp, sone tag	Bast fibres, ropes, twines, toes, old fishing nets, bags, etc.
15.	Curcuma varieties ...	Halad, Hardar, Amba Hardar, Ginger, etc	Whole plant but not the coims
16.	Cyperus Rotundus and varieties ...	Motha, Musta, Korai Gandula, Mutha	The whole grass
17.	Doemia extensa ...	Utarni	Outer bark
18.	Daphne Cannabina and varieties ...	Nepal paper plant	Inner bark and stem
19.	Ficus varieties ...	Bar, Vad, Pimpal and Similar trees	Inner barks of the young branches
20.	Girardinia Heterophylla ...	Mothi, khajati, Agia	Bast fibre of the plant
21.	Gossypium varieties ...	Kapas, cotton	Bark of the stems, cotton and waste of textiles, rags, linters, hull fibres.
22.	Heliacteres Isora ...	Murudsing	Bast fibres
23.	Hibiscus varieties ...	Bhendi, Ranbhendi, lal ambari, roselle and similar plants	The bark of the stem

	Botanical Name		Local Name	Parts Used
24.	Ischoemum Angustifolium		Sabai, Babhar grass	Whole grass, or leaves, ropes
25.	Lasiosiphon Eriocephalus	...	Rameta	Inner bark of the plant
26.	Linum Usitatissimum	...	Alasi, Javas	Bast fibres of the rejected stems
27.	Malachra capitata	...	Ranbhendi	Bast fibres
28.	Musa varieties	...	Plantain, Kela, Mouj, chavai, etc.,	The stem fibre
29.	Oriza Sativa	...	Rice Straw	Whole straw but not the tops
30.	Pandanus Odoratissimus	...	Kevada, Ketki	Leaf fibres
31.	Palmae	...	Palms of different varieties	Leaves, stalks,
32.	Saccharum Munj	...	Munj grass	Leaf, ropes new or old
33.	Saccharum Officianum	...	Sherdi, Sakar Sugarcane. Usa	The bagasse after extracting juice and sugarcane leaves
34.	Sanseviera zeylanica	...	Bow string hemp, Marul, Ghanas pan, Nagpuri	The leaf fibre.
35.	Triticum Sativa	...	Wheat, straw, gehu	Whole straw except tops
36.	Typha elephantina	...	bul-rush, jungli bajri, Pan kanis	Whole plant except the tops

Besides these several grasses and grain straws may be used for paper making.

The raw materials yielding paper-maker's cellulose may also be divided into three classes :—

(1) Cotton. This is almost pure cellulosic material yielding about 82-90% cellulose, the rest being water and other non-cellulose matters in small proportions. This type of raw material is simple in its treatment with alkalis.

(2) Pecto-celluloses. In this class of materials the cellulose is chiefly compounded with pectinous matters. The materials of this class require more drastic treatment than cotton or its manufactured waste. They are resolved by alkalis into cellulose either at low or high temperatures and pressures, and the non-cellulose passes into solution. Sunn-hemp, rice, straw, bamboo, grasses, plantain fibre, roselle fibre, etc., may be cited as examples of this class.

(3) Ligno celluloses. In this class the cellulose is mostly compounded together with lignin materials. Pure cellulose from this class is not easily obtainable even by alkaline treatment at higher or lower temperatures and pressures. They are required to be treated differently by calcium, magnesium or sodium bi-sulphites at higher pressures and temperatures. Generally woods come under this class of materials. Jute is also predominantly a ligno-cellulose but it is simpler than woods in chemical treatment. However jute does not give a prefectly white bleached pulp by the methods followed by the village paper-maker. Ligno-cellulose is coloured deep yellow when a drop of dilute aniline sulphate solution is put over it.

The materials comprising the first two groups are of interest to the Village paper-maker. Except jute the materials of the third group are outside his scope.

CHAPTER III

PROPERTIES OF CELLULOSE

As written elsewhere cellulose in a more or less purified form composes the chief material which is converted into paper. This cellulose is the main substance produced in the vegetable kingdom during its growth. It is the backbone or skeleton of the plant-life. The cellulose never occurs free except in cotton. It is always associated with pectins or gummy and mucilaginous materials, resins, oils, colouring matters, waxes, starchy material, etc. Such substances may be termed non-cellulose materials to distinguish them from the cellulose.

PROPERTIES OF CELLULOSE. When burnt, cellulose gives carbon. If a glass plate is held over the flame while the cellulose is burning, it will be noticed that water condenses on the underneath surface of the plate showing that water is one of the products of combustion.

Proportions in which carbon, hydrogen and oxygen are combined to form cellulose are :—

Carbon	...	44.40%
Hydrogen	...	6.17%
Oxygen	...	49.43%

Cellulose is a tasteless, odourless and white substance. It does not dissolve in water or alcohol or in any other simple solvents. Cellulose is an inert or inactive material. It is not acted upon within certain limits by alkalis or oxidising agents such as chlorine, bleaching powder or potassium permanganate, but the non-cellulose matters are attacked by these chemicals. It is this property that is taken advantage of, in the preparation of cellulose by the paper-makers.

Acids especially of the inorganic type such as hydrochloric, sulphuric, nitric, should never be used in the treatment of the raw materials, as they deteriorate the quality of cellulose thereby making it weaker or useless for paper-making.

Micro-organisms or bacterias also attack the cellulose and thus destroy it. It will be observed that if prepared pulps are

kept in receptacles for some time, fermentation sets in the pulp emitting putrid smell. Hence wet pulps should be put to immediate use, without storing them for a longer period.

For the production of writing and other similar paper removal of non-cellulose matter must be as complete as possible, while for wrapping paper, card-boards, etc., this removal need not necessarily be complete.

The processes involved in separating the cellulose from the fibre may be put into equation form thus :—

(1) Fibre = cellulose + non-cellulose matter.

(2) Fibre + water hot or cold = cellulose + water insoluble non-cellulose + water soluble non-cellulose.

(3) Fibre in (2) washed = cellulose + water insoluble non-cellulose.

(4) Washed fibre from (3) + alkali = cellulose + residual non-cellulose + alkali soluble non-cellulose.

(5) Fibre in (4) washed = cellulose + residual non-cellulose (useful for making wrapping paper, etc.,)

(6) Fibre from (5) + bleaching powder = cellulose + residual non-cellulose destroyed by bleaching.

(7) Fibre from (6) + washing = cellulose or writing paper material.

Different raw materials yield different percentages of cellulose (See Appendix A.)

Although cellulose having the chemical formula $C_6 H_{10} O_5$ is a class name, the celluloses obtained from different materials differ in paper-making qualities. They fall in two groups: alpha or cotton cellulose group and beta or straw cellulose group. The alpha cellulose is more resistant to alkalis and bleaching agents, cotton, linen, linseed, and sunn-hemp give predominantly alpha celluloses. Hence paper made from such fibres is more durable. Beta cellulose is less resistant to the action of strong alkalis, oxidizing agents such as bleaching powder etc. Grasses, straws, jute, wood etc., yield predominantly beta celluloses, chemical wood pulps are intermediate between the two. Hence paper made from such materials is

weaker than the paper made from the cotton group, although it is useful for ordinary purposes.

Cellulose froms a vast industry. It is the chief substance in the manufacture of textiles such as cloth, sacking, canvass, ropes, yarn, paper, artificial silk, celluloid, photographic and cinema films, paints and varnishes, explosives, and a host of other articles.

CHAPTER IV

PAPER-MAKING PROCESSES

The manufacture of paper is both a chemical and a mechanical process.

The processes involved are :—

(1) Preliminary treatment: cleaning, sorting, and cutting of the fibrous material, or preparing the material for subsequent chemical and other treatments.

(2) Chemical treatment: retting or boiling with alkalis and then bleaching it.

(3) Beating or the operation to reduce the chemically treated material to pulp proper.

(4) Sheet formation.

(5) Sizing the sheets to make them non-absorbent.

(6) Smoothening or glazing the sheets.

(7) Cutting the sheets into suitable stationery.

The first three processes are destructive processes in that the material is reduced to smaller and smaller dimensions; so also the non-cellulose matters are destroyed or removed in each consecutive process to convert it into pulp. These processes come under the general heading "Pulp-Making."

The last four processes are contructive processes in that the reduced fibres in the pulp are assembled together to form a sheet, which is made impervious to ink by sizing, and afterwards made smooth by glazing so that the pen may not be obstructed while writing, and is then brought into a convenient size by cutting.

CHAPTER V

PULP-MAKING (Theoretical)

THE object of the paper-maker is to get a fabric suitable to write upon. In textile manufacture also the object is to get a fabric. But the difference between the two, is that while the textile manufacturer assembles several fibres or filaments, to form what is called thread or yarn by the process of spinning as a preliminary to the formation of fabric by the process of weaving, the paper-maker follows just the reverse of the process, in that instead of assembling the fibres together to make yarn, he reduces them chemically into cellulose aggregates which are afterwards disintegrated into their distinctly individual units or their sub-divisions as a preliminary to sheet formation. This is what is termed pulp-making.

The first stage in this process is to free the fibrous cellulose from the non-cellulose matter with which it is bound together in the raw material, by the use of chemicals which do not act upon the cellulose but act upon the non-cellulose matter in a way which allows of the latter's easy removal. The second stage is to separate the cellulose fibres into their distinctly ultimate units or their sub-divisions, each such unit having a separate existence. This is done by a mechanical process called 'beating'.

Chemical treatment for the separation of cellulose from the raw material. The chemicals that are used for this purpose are :—

A. Alkaline agents : (*i*) Lime, (*ii*) Soda ash, (*iii*) Sajjikhar (*iv*) Sajjimatti, (*v*) Papadkhar, (*vi*) Caustic soda. (*vii*) Soap.
B. Bleaching agents : bleaching powder.
C. Antichlors : (*i*) Hypo or sodium thio-sulphate, (*ii*) Sodium sulphite.

A. Alkaline treatment or soda process. The alkaline agents mentioned above fall under two classes.—

(1) Mild alkalis such as soda ash, sajjikhar, sajjimatti and papadkhar. All of these contain sodium carbonate in varying proportions. Soda ash is almost pure sodium

carbonate and is manufactured from common salt by a series of chemical processes, and at present is an imported article, while the rest are indigenous to India. The action of these alkalis is mild. They do not burn or irritate the fingers or the tongue. When dilute acid is dropped over these mild alkalis, they give out bubbles of a gas known as carbon-dioxide.

(2) Strong alkalis such as caustic soda and lime. Caustic soda is prepared from common salt by electrolysis or from sodium carbonate by the action of quicklime. In subsequent pages of this book the use of a mixture of lime with sajjikhar, sajjimatti or papadkhar is mentioned. In such cases it should always be understood that the action is that of caustic soda formed by the interaction between the two chemicals. Caustic soda is stronger in its action than the mild alkalis. It irritates the fingers. With dilute acids it does not give any bubbles. If dry caustic soda is left in the air it absorbs moisture and becomes liquid. Hence it should be kept in air-tight containers.

NOTE :—When caustic soda is made from indigenous materials it need not be concentrated as for soaps. A lye of about 2^{0} to 3^{0} Be' is quite sufficient in the boiling process, while a lye of about 5^{0} to 6^{0} Be' should be used in the retting process.

[For full details of the alkalis especially those made from indigenous raw materials, see the booklet on "Soap-making as a Cottage Industry by the use of Indigenous Raw Materials" published by the A. I. V. I. A., Wardha].

In separating the cellulose from its parent substance advantage is taken of the properties of cellulose, *viz.*, that it is not acted upon by alkalis and bleaching agents within certain limits of concentration while the non-cellulose matters such as resins, gums, waxes, etc., are dissolved or acted upon by them. The resulting products are removed by washing. If the degree of concentration of the alkaline solutions increases more than 4 to 5% of caustic soda then even the cellulose is attacked when the temperature is high, *ie.*, at the boiling point. Hence, if the removal of the non-cellulose matter is not complete in

one operation it is better to repeat the operation than to use caustic soda at a higher concentration especially in the boiling process. The concentration of the solution should represent 1 to 1½ lb of caustic soda in 10 gallons of water. Sodium carbonate in soda ash, sajjikhar, papadkhar, etc., as well as lime are milder in action and consequently are not largey used. The lignin material in ligno-celluloses such as woods is not completely removed by the alkalis. It is removed by other chemicals, *viz.*, sodium calcium or magnesium bi-sulphite or sulphite, at high temperatures and pressures. Hence the process is known as sulphite process. Sometimes woods and even bamboo are digested with a mixture of caustic soda and sodium sulphide. This process is known as sulphate process. Properly speaking this is a sulphide process, but it is called a sulphate process because sodium sulphate is first converted into sulphide which is ultimately used with caustic soda in this process. As different raw materials contain different non-cellulose materials, the proportion of alkalis required varies with each material.

There are three different processes to which the raw material may be subjected to treat it with alkali. They are.—(*i*) Retting or cold process (*ii*) Boiling process. (*iii*) A combination of the retting and boiling process.

(*i*) Retting process. In this the reaction between the raw material and the alkalis is carried on in the cold. Consequently it takes a very long time for the alkalis to act upon the non-cellulose matter. In actual practice the material is mixed with the required amount of the alkalis and kept aside for some days, usually from one to two weeks, at the end of which it is washed and again treated with the alkalis as before. The process is repeated more than once till the raw material is almost free from the non-cellulose matter. In this process beating at intervals under the dhenki is also carried on simultaneously with the retting to ensure better action of the alkalis and separation of the impurities from the fibre. Although the time taken in this process is long, still the separation of the fibrous cellulose is brought about in a natural way in the process of fermentation which helps the beating

operation. So also the natural characteristics of the fibres are better preserved than in any other processes and hence the paper made is stronger and more durable. This process was mainly followed by the old kagzis throughout India, so also in the earlier stages when paper-making was introduced into Europe (See also Old Paper-Making Processes, Chapter I).

(*ii*) Boiling and digestion process. In this process the chemical action between the non- cellulose materials such as gums, resins, etc., and the alkalis is brought about at higher temperatures. This is done in two ways. One is to boil the material under ordianary atmospheric pressure and temperature and is known as open boiling. The other is to digest it at still higher temperatures and pressures. This is known as pressure boiling or digestion.

In the retting process the reaction between the non-cellulose matters and the alkali takes a very long time. Moreover the removal of the non-cellulose matters is not always complete even after a considerable time. This romoval is mostly dependent upon the way in which the non-cellulose matters are combined with the cellulose in the original raw material. In such cases the material is either ordinarily boiled at the atmospheric pressure, or in the case of still harder materials where ordinary boiling is not sufficient, they are digested at higher pressures and temperatures.

As an instance, sunn-hemp or gunny bag waste, if retted, would take about two months' time for the removal of this non-cellulose matter. Even then a very small portion of non-cellulose matter may remain in the pulp, although a paper could be made from such pulps as in olden times. But the boiling process shortens this period to about eight hours, or in the case of digestion under pressure it may be reduced still, to three or four hours with complete removal of the non-cellulosic matters. Take another instance of bamboo or aloe fibre. In these cases the non-cellulosic matters are not appreciably affected by the alkalis even though they may be retted for three or four months, or ordinarily boiled for a day or two. But if the same material is digested under pressure the reaction is complete within six or eight hours' time and the cellulose obtained is almost free from non-cellulose materials.

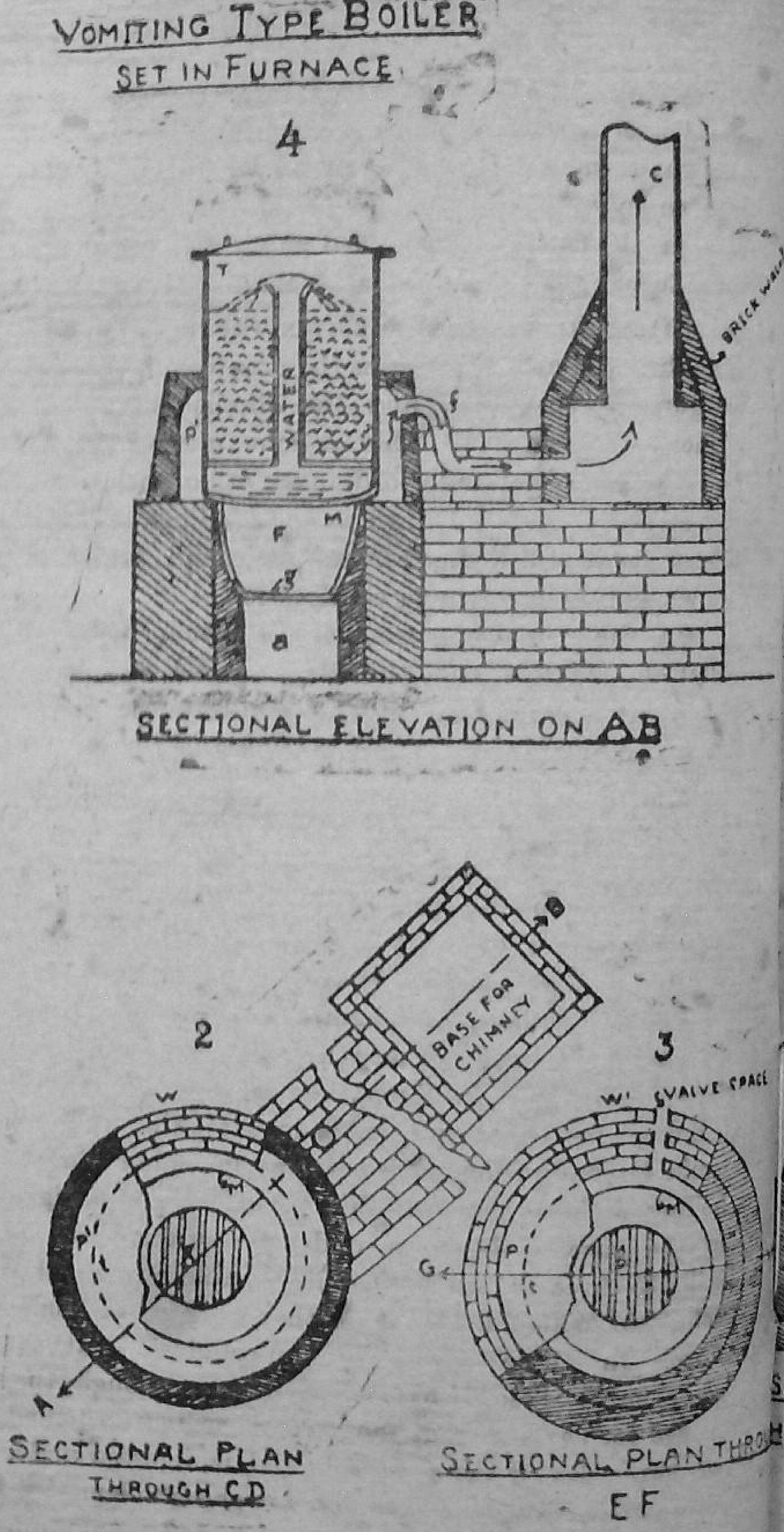

Fig. 1-a Constructions of an eco

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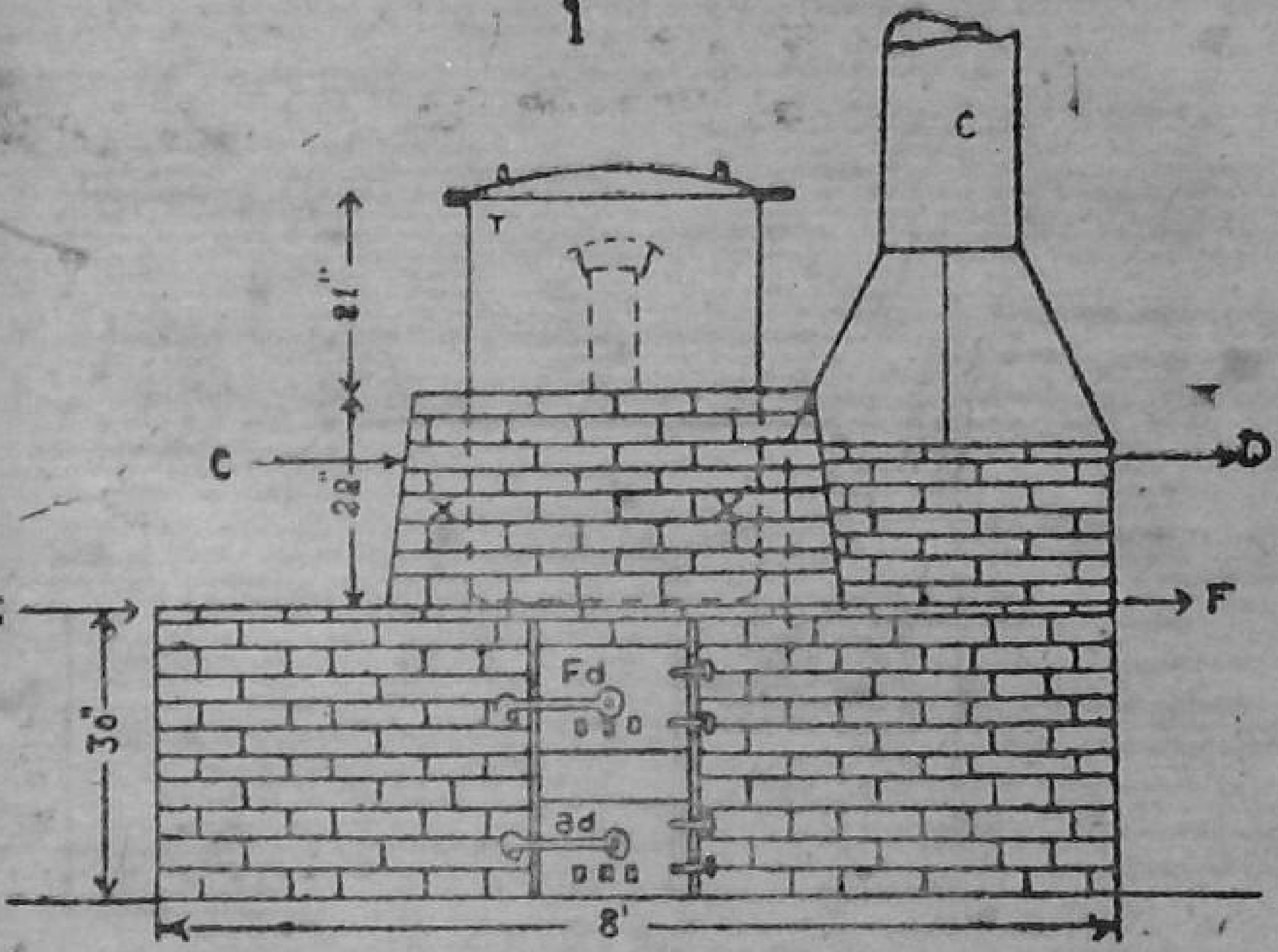

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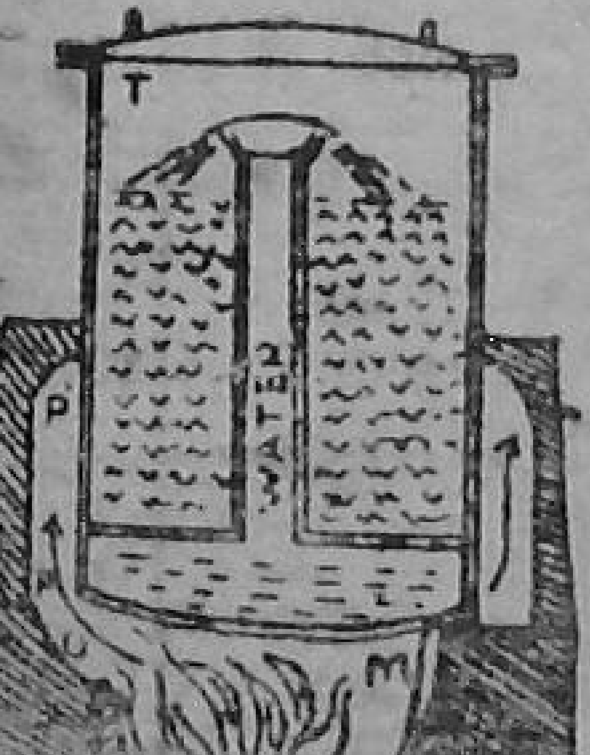

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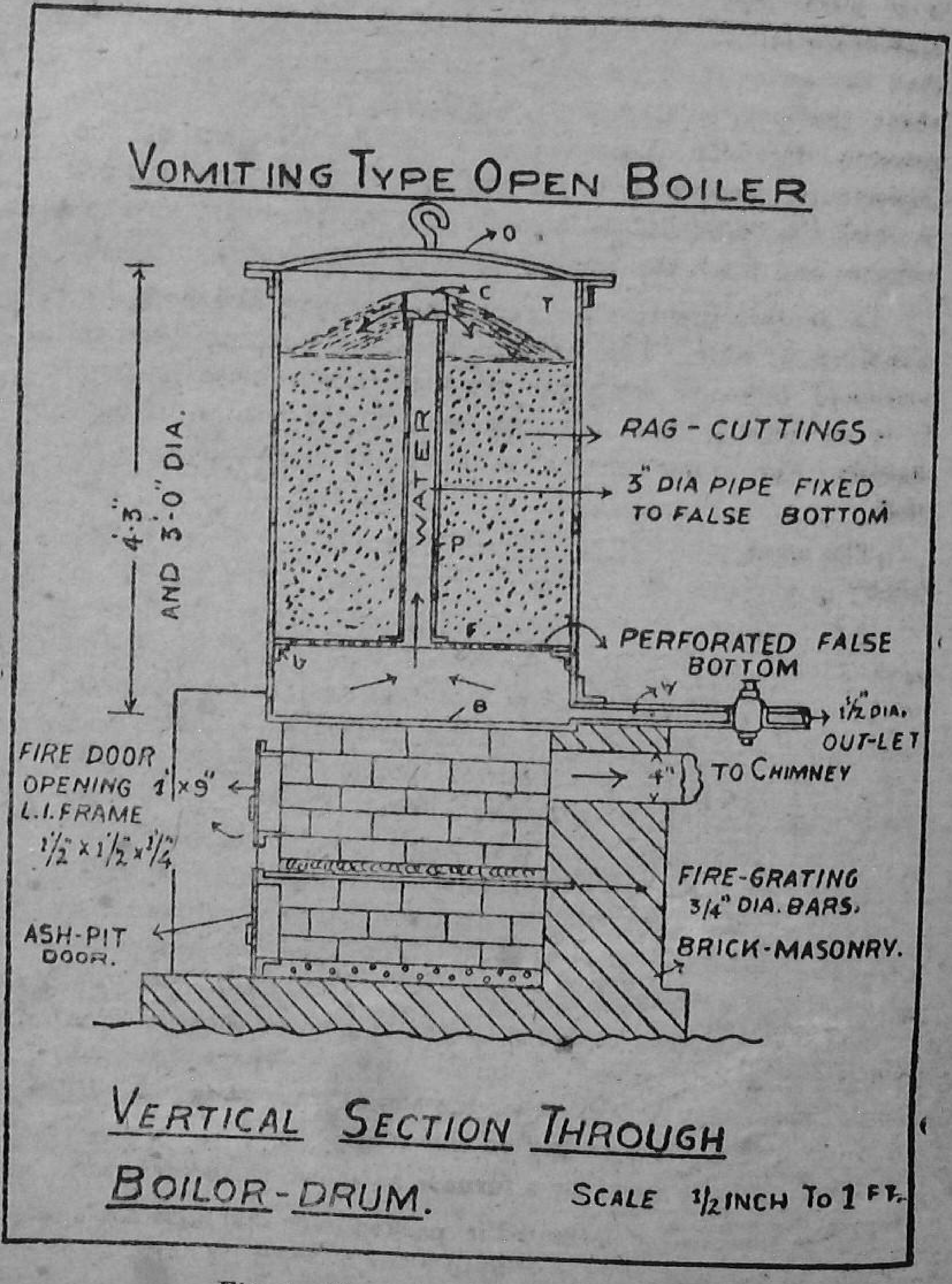


Fig. 1—Vomiting type open boiler

Another advantage in this process is that the material is softened, especially if it is digested under pressure, which is of advantage in the subsequent operations of beating and sheet formation. It will be noticed as described elsewhere that the softer the fibres the better the felting. The choice about the particular process either, retting, open boiling or pressure digestion depends upon the availability of the implements, the nature of the raw materials, *ie.*, the manner in which the non cellulose constituents are combined with the cellulose and upon the quality of the paper desired.

In modern practice the pulps are generally bleached with bleaching powder. The amount of the bleaching powder consumed depends upon the residual non-cellulose matters. It is at once evident that the lesser the amounts of such matters the lesser the amount of the bleaching powder used.

The material is boiled either in an ordinary or in a special boiler, or cooked in a digester under pressure.

(a) Vomiting boiler: Open boiling system. A suitable tank for open boiling is constructed as shown in Fig. I. It consists of a cylindrical tank T 4' high and 3' in diameter having either a dish shaped or flat bottom B of 3/16" thick mild steel plate. The cylindrical portion is made of 1/8" thick plate. A perforated false bottom F 3/16" thick with ½" holes, rests loosely on four angle iron brackets b, at a distance of about 4" to 5" from the real bottom B. A hollow pipe P. 3'-3" long and 3" in diameter is firmly fixed into this false bottom by a flange F. A dish shaped cap C supported on four legs is fitted at the top of the pipe P. An outlet valve V with 1½" pipe is fixed quite close to the real bottom B of the tank. This serves to drain away the spent lyes. An angle iron ring is welded at the top of this tank. A dish shaped cover O rests loosely on this ring.

This tank is fitted on a furnace as shown in the drawing.

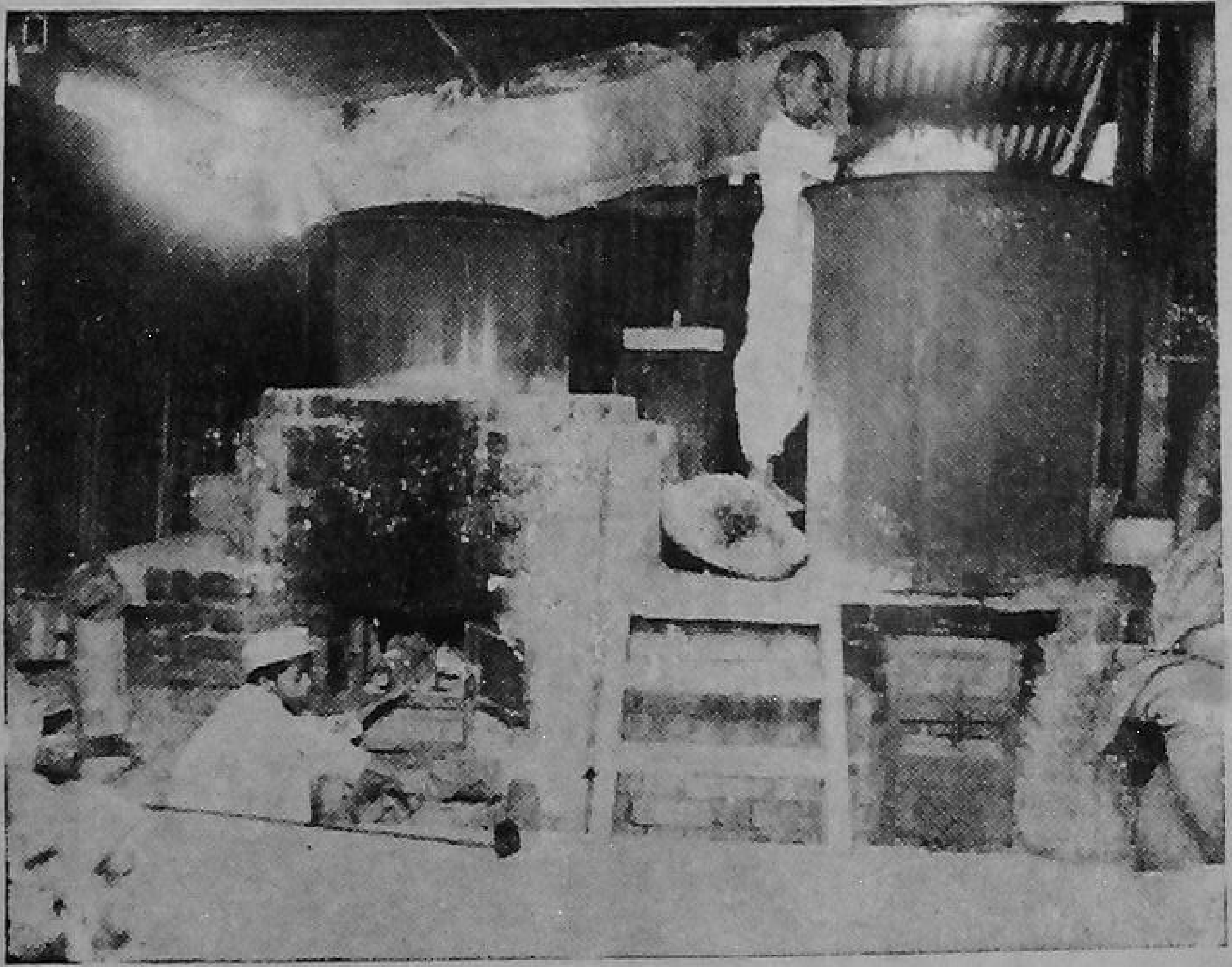
The material to be boiled is packed over the false bottom F round the central tube P upto 3" or 4" from its top. The necessary amount of dilute caustic soda solution is poured over the material so as to completely submerge it. Now the

top cover O is put on the tank and fire lighted in the furnace. The liquid between the false and the real bottom begins to get heated and rises through the pipe P. Ultimately when this liquid begins to boil vigorously it gushes with force through the pipe P and dashing against the concave surface of the cap C spreads over the surface of the material.

In the meanwhile the liquid over the false bottom percolates through the material and reaching to the bottom fills the empty space between the false and real bottoms. Again it gets boiled and is forced out through the pipe as before. In this way the cycle goes on automatically, at some periodic intervals, thereby keeping the alkaline lye in circulation and well distributed.

Note :—For digesting large quantities of raw materials, a big digester may be made on the same principles with suitable modifications. But this will necessarily come under the Boiler Act.

Construction of the economic furnace. In the old style furnace gases pass directly to the chimney (shown by arrow line, fig. I) after heating only the bottom of the tank T. In order to economise the fuel, a special furnace (see fig. I a) is constructed in such a way that the gases circulate half way round the tank T before the exit to the chimney, thereby giving more heating surface to the tank. At I is shown the front elevation or the view of the tank and the chimney imbedded in the brick work. This part of the tank is shown by dotted lines at X. The doors for the ash-pit and the furnace proper are shown at a d and f d. They can be opened or closed as required. If the tank and the brick constructions surrounding it, is cut horizontally at CD and the tank removed it will have a view as shown at 2, the sectional plan through CD. In this plan G is the fire grating, M is the mouth of the furnace; the position of the tank is shown by dotted lines at t (see 2 & 3) p' (see also 4 or 5) is the hollow pocket between the tank and the brick work which surrounds it; w is the partition wall which extends from the bottom of the floor right up to the top of the brick work; it prevents the short circuit of the hot gases to the flue pipe f which is close to the wall at the right hand side (see also at 4). The hot gases surrounding



View of open boiling
Left tank in economic furnace, Right tank in old furnace

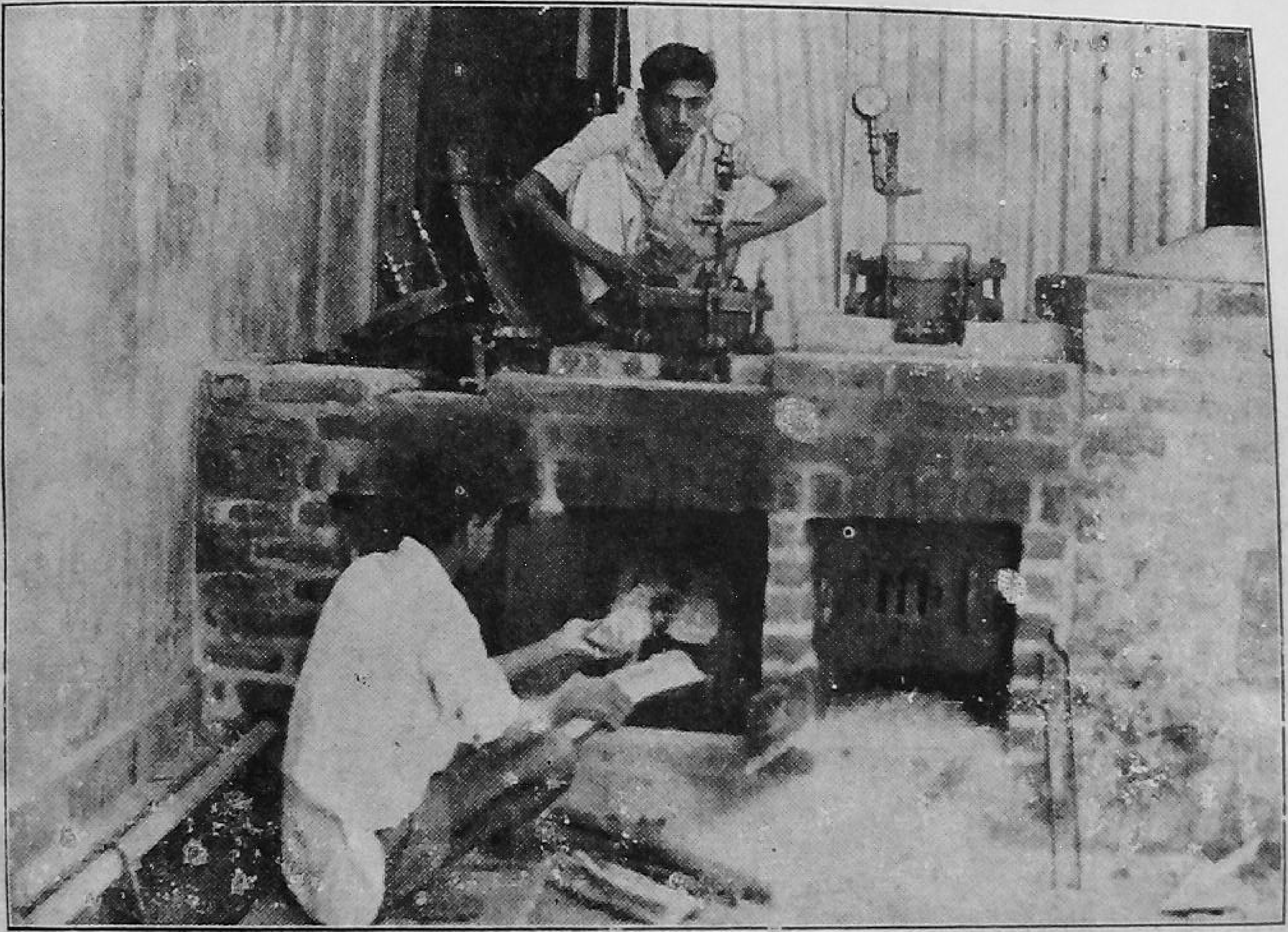


Plate 1.—Digestors

the tank from the left side of the wall pass to the chimney through the flue pipe f at the right hand side.

In the sectional plan (3) on E F is shown the view at the bottom of the tank if the constructions are cut at E F, *i.e.*, at a place where the tank rests on the floor. g is the fire grating over which the fuel burns. The tank T shown by the dotted line t, rests on the floor shown by the hatched lines. The partition wall w starts from w'. The hollow pocket p in the floor allows upward passage to the hot gases from the furnace.

The sectional elevation on A B gives the view if the tank with the furnace and the chimney is vertically cut in the direction of AB (see 2). The ash-pit is $2\frac{3}{4}$'×16"and 12" deep from the grating g. Over this pit lies the fire grating g made either of round bars fixed in a suitable frame or cast iron. For the sake of convenience the grating may be made in 3 parts, so that the grates may be replaced without disturbing the other structures.

Although in the plans, the view of the fire grating is shown by circular lines in the actual constructions it is rectangular in shape, the size being 2'×16"×1" thick and is fixed almost centrally to the tank. The mouth of the furnace is 16" high from the grating. The inside wall of the furnace is made almost of crucible shape except a portion where the hollow pocket is made for the upward passage to the hot gases. See arrow line along O P on the sectional elevation on G H (5). The tank illustrated here is $3\frac{1}{2}$' high and $2\frac{1}{2}$' in diameter and is surrounded by a sloping brick wall 6" thick and 1'-9" high, leaving a hollow space of 3" between the tank and the wall.

When the furnace is in operation the hot gases from the burning fuel heat the bottom of the tank and finding their way through the opening o (see at 5) in the furnace pass through the hollow pocket (see 3 & 5) and after surrounding the hollow space p' find their way to the chimney through the flue pipe f which is fixed close to the partition wall w which prevents hot gases from finding a short passage to the chimney. With this construction more heat from the burning fuel is utilized owing to the increased heating surface of the tank.

This considerably economises the fuel consumption. Whereas in the former case 100-120 lb of wood fuel were required for a charge of 125 lb of rags for 3 hours' boiling, in the new furnace the fuel consumption comes to about 50 to 60 lb.

(*b*) DIGESTERS. The digester consists of a cylindrical shell A 21" high and 9" in diameter having a flat or dish shaped bottom. It is made either out of 3/8" mild steel plate or sound old gas cylinders as are used for holding soda water gas. The lid L consists of a circular M. S. plate 3/8" in thickness and of a suitable diameter. Two concentric rings are welded into the plate to form a groove ¾" deep and a little more than 3/8 of an inch in width so that the top of the cylinder closely fits into it. The top of the shell and the groove in the lid are turned true to each other. The lid L is fastened to the shell A by means of sliding bolts and clamping arrangements. Asbestos packing is inserted into the groove before fastening it to the shell so that steam or air may not leak through. Pressure gauge, safety and exhaust valves are fitted into the lid L. The capacity of any digester should not exceed 4/5 of a cubic foot or 5 gallons of water. A loose cage C is made of wire cloth with a hollow tube fixed centrally. The top of this central pipe should be fitted with a cap as in vomiting boiler to prevent splashing of liquids against the cover. This cage serves to hold the material to be digested. In certain cases the cage may be dispensed with. All the parts of the digester are strongly welded to bear the necessary pressure. It is preferable to test the digester with hydraulic pressures 3 to 4 times that to be actually used for digestion. The safety valve is adjusted to the maximum pressure to be used. The digesters are fixed into the furnaces. For details of the digesters and furnaces see Figure 2, and Plate I, Page 30.

The digesters help the removal of the non-cellulose matters from materials such as bamboos, aloe fibre, linseed fibre, etc., better than open boiling. The pressures used for digestion vary between 25 to 60 lb per sq. inch. The material so digested is softer and bleaches better than that from any other process. The time of beating is also lessened subsequently.

When a material is to be digested it is packed in the cage round about the central pipe, or in case the cage is dispensed with, it is directly filled into the shell. Next the required quantity of caustic soda or soda ash dissolved in water, is poured into the digester. The quantity of the solution should be so adjusted that the lye not only completely submerges the material into the digesters but remains about half an inch or so over it. The digester is never filled to the full but 3 or 4 inches under the top, thereby leaving space for the expansion of the boiling liquids and steam. Next the lid is put on and fastened by the clamping bolts. As has been explained before asbestos packing is put in the grove to ensure the digester being leak proof. Next, fire is lighted in the furnace. The exhaust valve is kept open for the escape of the air. When steam begins to come out the valve is closed. Soon the indicator of the gauge begins to rise. When it shows the required pressure on the gauge the fire is carefully made slow, so that the pressure remains constant. If the pressure used for digestion is that at which the safety valve is adjusted, it will blow off the steam maintaining the pressure constant. The furnace should be charged slowly with fuel to avoid danger of explosion through excessive pressure. The safety valve, pressure gauge, etc., should be kept clean and in perfect order and should be periodically tested.

At the end of the digestion period which is generally 4 to 6 hours, the fire in the furnace is put out and the exhaust valve is slightly opened, which allows the steam to escape, relieving the pressure in the digester. When the steam ceases to escape through the exhaust valve and the indicator reverts to its original position of rest, the clamping bolts are made loose, the lid is removed and the cage is taken out, or when a cage is not used the contents are ladled out and the digester is cleaned for a fresh charge.

In order to economise fuel in the subsequent charge the exhaust steam from the first charge is used with suitable pipe arrangement on the valve for heating the alkaline lyes before adding to the next charge.

(*iii*) COMBINATION OF THE RETTING AND BOILING PROCESSES.

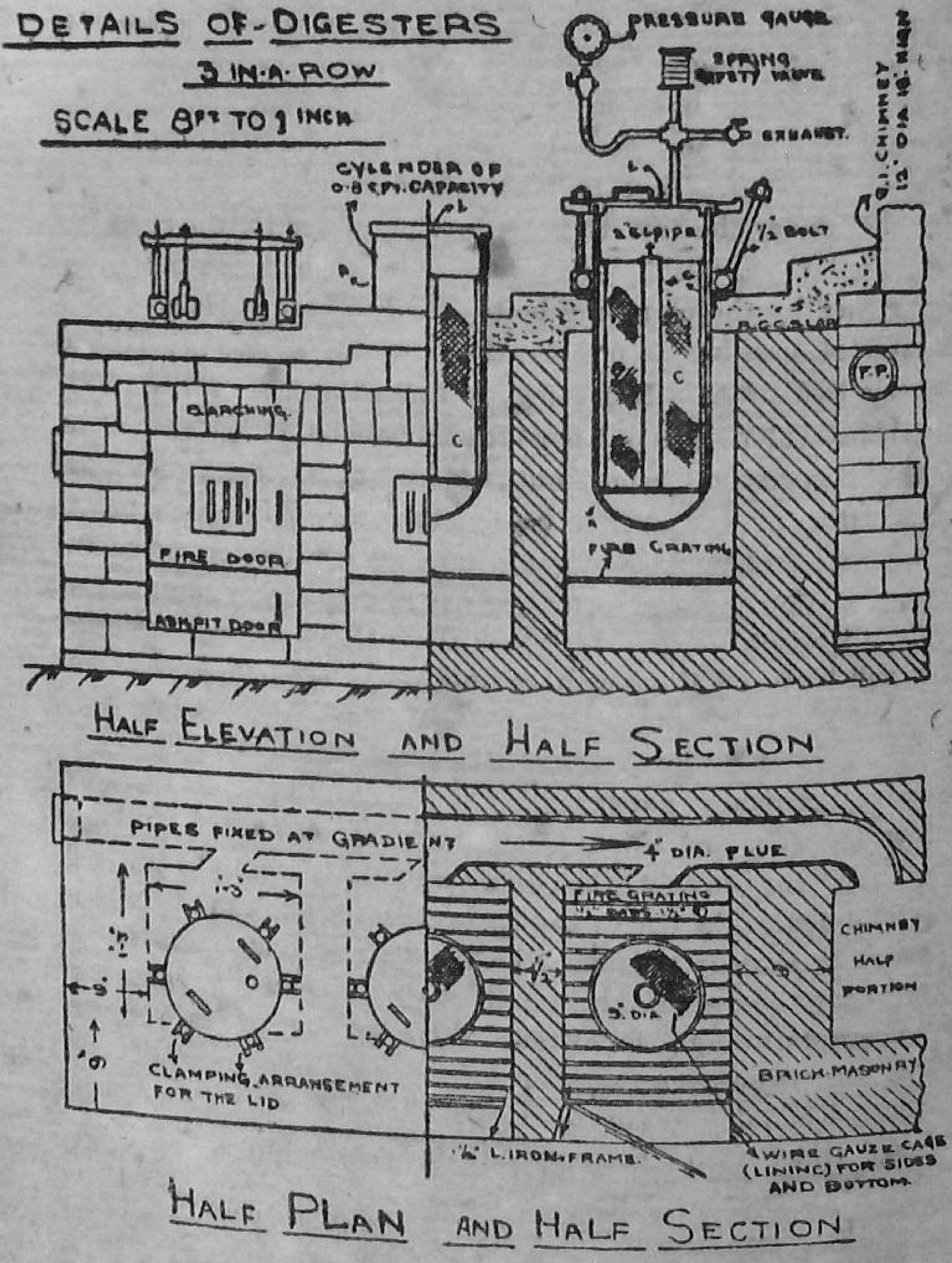


Fig. 2—Details of Digesters

Whenever it is desired to shorten the time of retting, the material may be boiled after it is retted for some time, thereby reducing the repetition of the retting operation. This will also have the advantages of both the processes, *viz.*, better separation of the individul fibres by retting and better elimination of the non-cellulose matter and reduction in time by boiling. The time of boiling in the process need not be longer than one to two hours. In this process conditions may be varied to suit individual requirements, as sometimes the boiling may be done before or after the retting operations.

In the case of blotting and filter paper, the rags are boiled or dige:.:ed with caustic soda or lime and without washing are kept in heaps for retting for some weeks and are thus advantageously rendered softer and tender.

Note :—At the end of each operation the material should be thoroughly washed to remove the acted non-cellulose matter.

B. Bleaching treatment: In the *alkaline* treatment most of the non-cellulose matters are removed. However this removal is never complete as it mostly depends upon the way of treating the raw material, whether retted, boiled or digested, so also upon the concentration of the alkalis used in the treatment. In the hand-made paper-making the above treatments are not so drastic as in mill practice. Even after drastic treatment the non-cellulose constituents are never completely removed but they remain as residues in the treated material in more or less proportion.

These residual non-celllouse matters are removed by a bleaching process. Bleaching is a process of oxidation, *i.e.*, the oxygen liberated from a suitable oxidizing agent destroys the colouring and other materials except the cellulose. These are either hypochlorites of calcium or sodium, postassium permanganate, hydrogen peroxide, chlorine gas. They destroy the residual non-cellulose constituents but do not act upon the cellulose proper. Of all these different bleaching agents calcium hypochlorite, commonly known as bleaching powder is generally used for bleaching as it is cheap and easily available in the market in normal times. It is obtained by passing

chlorine gas into slaked lime into which the gas is absorbed, according to the chemical equation :—

Slaked lime		Chlorine gas		Calcium hypochlorite (bleaching powder)		Water
$Ca(OH)2$	+	$Cl2$	=	$CaOCl_2$	+	H_2O

This hypochlorite liberates oxygen from its solution in water according to the equation :—

Bleaching powder		Calcium chloride		Oxygen
$CaOCl2$	=	$CaCl2$	+	O

This oxygen is in nascent condition.

This nascent oxygen acts upon the residual non-cellulose matters into products which are removed by water in the washing process. The quantity of bleaching powder required to make the pulps white, depends upon the amount of the non-cellulose matters remaining in the raw material after the alkaline treatment. The loss in weight of the final pulp will also be in proportion to the non-cellulose constituents destroyed by the bleaching agent over and above those removed in the previous alkaline treatment.

The value of the bleaching powder depends upon the available chlorine in the powder. The bleaching powder of commerce contains about 35% of this active chlorine. It is an unstable compound. It deteriorates and loses its active agent when kept open for a long time or in moist climate when it also absorbs moisture from the air and becomes wet. Hence it should be stored in air-tight containers. While opening the big containers care must be taken to keep the mouth away from it otherwise the chlorine liberated is inhaled in the lungs causing suffocation and irrigation in the throat. If at all the gas is inhaled milk should be drunk and ammonia inhaled. Chlorine gas is not a deadly poison. With careful handling there is no danger. Moreover with small quantities that the small manufacturer has to deal, it is harmless. For making the solution of bleaching powder see directions under "Practical Pulp-Making" (infra) Chapter VI, page 53.

Sodium hypochlorite :—This is not a commercial article but is prepared by passing chlorine gas into caustic soda according to the equation :—

Caustic soda	Chlorine	Sodium chloride or common salt	Sodium hypochlorite	Water
$_2NaOH$ +	Cl_2 +	$NaCl$ +	$NaOCl$ +	H_2O

This sodium hypochlorite liberates oxygen as per equation $NaOCl = NaCl + O$(nascent) and hence sodium hypochlorite acts on non-cellulose matters in the same way as bleaching powder. This agent is also prepared by electrolysing common salt solution of about 20% strength in a battery of cells specially made for it. The cells consist of a wodden or cement tank in which compressed graphite or carbon plates are placed at some distance apart in such a way that they afford a zig-zag passage to the salt solution. The inner faces between the consecutive plates constitute one cell. Each cell requires about 3·5 volts and a current density in amperes according to the size of the cells. Electrolysing action on common salt solution is as under :—

Common salt	+ Water		S. H. Chlorite	Hydrogen
$NaCl$	$+H_2O$	yields	$NaOCl$	$+ H_2$

The sodium hypochlorite remains in the solution and hydrogen escapes into the air. Sodium hypochlorite is an unstable compound and should be prepared freshly before use. The other bleaching agents are not commonly used and hence they are not dealt with.

C. Antichlor treatment.—The cellulose freed from all the impurities in the bleaching treatment contains some residual bleaching agent even after repeated washings. This residual bleaching agent in the cellulose is harmful, as it makes the pulp weak through oxidation, and consequently paper prepared out of it becomes comparatively weak, brittle and friable and after some time also discoloured. Hence this is required to be removed by treating it with antichlors such as hypo *i.e.* sodium thio-sulphate or sodium sulphite, whose action is to destroy the residual bleaching agent.

Note :—The bleaching treatment should be avoided in the case of paper intended to last for a long time such as documentary, ledger, certificate, etc., In such cases the raw material chosen for such paper should be of the best quality. Sun-blea ch-

ing described under "Practical Procedure for Pulp-Making" (infra) should be followed. If at all bleaching is given it should not be drastic and should be well controlled. The washing should be perfect.

The material at this stage is known as half-stuff.

D. Beating:—In the chemical processing of the raw material the fibrous cellulose is freed from its impurities, but even in this condition it is not ready for converting it into paper. If used as such, the paper formed will be uneven, if at all it is possible to make it. Cellulose is required to be brought into proper condition by mechanical means. The operation is termed the beating operation. It is an important operation in the manufacture of pulp. On it depends the quality of the paper to be made. The objects of beating are many. The cellulose fibres obtained in the chemical treatment are aggregated together into bundles. They are required to be separated into distinct, individual units of the ultimate fibres or their sub-divisions having an independent existence in the water of the vat, so that they may be evenly woven or felted together in the sheet formation. If this separation is not complete than the unreduced fibres or knots appear as speaks in the paper, making it unsightly and sometimes also unfit for use.

Here it is necessary to define the terms *fibre* and *ultimate fibre*. *Fibre* is a term that is applied to a substance in its raw state before it is chemically treated. It may be in its original natural form or in a manufactured form or its wastes as ropes nets, cloth, rags etc. *Ultimate fibre* is a term applied to the small cellulosic fibres of which the raw fibre is composed. These are obtained in the chemical treatment by removing the non-cellulose constituents with which the cellulose fibres are mixed or compounded together. These ultimate fibres are also called cellulose fibres. They vary in length and breadth in different fibres or paper-making raw materials. In the case of long cellulosic fibres they are required to be reduced into small lengths. Thus the objects of beating are (1) to separate the individual fibres from their clusters in the half stuff. (2) to

reduce them to small lengths and (3) to soften them. During sheet formation soft fibres felt together better than stiff ones whose felting qualities are less as they remain straight without bending, which is a disadvantage for a good paper.

The first and the third objects are accomplished by rubbing, brushing and teasing the fibres. While the second object is accomplished by tearing and bruising, but not by cutting them.

The cellulose fibres have an important property of felting together to form the web or sheet.

The strength of the paper depends upon these felting properties of the fibre. More the felting the better is the sheet. These felting properties of the fibres are lost if they are cut clean as with a pair of scissors or sharp cutting instruments. This important factor is to be kept in mind when reducing the fibres to small lengths. In the beating operation not only the natural felting properties of the fibres are to be preserved but they should be increased whenever possible. This is accomplished by crushing, stamping or hammering or by tearing, by which not only the fibres are sub-divided in length but the ends of such sub-divided fibres get a bruised or brush-like appearance. In order to get an idea of such a phenomenon take a small green stick or a long green stem of a plant and give it a hard blow with a heavy hammer so that it is divided into two parts and notice the bunch or brush-like appearance at the hammered ends. The same thing happens to fibres under the hammering action of the dhenki and mechanical stamper or the blunt knives of the hollander beater. These bunches in the fibres increase the felting property as they give more links or interlocking when they come close together by the vatman's strokes in the sheet formation.

During these several operations in the process of beating yet another phenomenon takes place. As the half stuff is being beaten to pulp in contact with water it assumes a certain characteristics. The pulps in the beater go on absorbing more and more water as the beating progresses. At the commencement of the beating operation, there is a tendency of

the water to separate from the stuff. If a small portion of the stuff at this stage is taken into the hand, it will be found that the water is separated more easily and quickly even without pressing. But as the beating progresses it will be noticed that more and more water is absorbed into the bulk of the pulp and the separation of water from it becomes less and less and ultimately when the beating is sufficiently prolong ed, the pulp can hardly be distinguished from the water. It some-what looks like thick curds or gruel. A ball of the pulp taken into the hand hardly separates any water from it unless it is pressed. Such pulp when rolled in the palms of the hands feels exactly like a ball of butter. The pulp at this stage has a greasy or buttery feel. This phenomenon is known as the "hydration of cellulose." During this hydration the fibres are more and more swollen with the absorption of water, and tend to assume a jelly-like appearance.

The quality of paper is governed by the degree to which the pulps are hydrated and beaten. It is not that all the pulps are beaten to the same degree. According to the degree to which the pulps are beaten and hydrated they are called free or wet pulps and the process is known as " Free beating " or " Wet beating " of pulps. There are intermediate degrees between the two. The term " free pulps" is applied to such pulps as readily part with their water on the paper lifting moulds. They are beaten within the shortest possible time without bruising or hydrating the fibres. Such pulps are used for filter, blotting and other absorbent papers. Strength is not required in such papers.

The term " wet pulps " is applied to such pulps as do not readily part with their water on the paper lifting moulds. This condition is attained by beating the pulps for a longer time (8-12 hours in case of rags) so that the fibres are well bruised and well hydrated. Such pulps are used for making strong papers such as bank notes, ledger, documentary paper etc.

For writing purposes the pulps are beaten to an intermediate stage *i.e.* neither free nor too wet. (For further details about the manner in which this several conditions are attai

ned, refer to beating under "Practical Procedure for Pulp-Making" (infra) Chapter VI.

The raw materials such as cotton, sunn-hemp, linseed fibre or flax, agia, nilgiri nettle, rhea fibre mudar fibre etc., or their manufactured products such as Ropes, cloth etc., yield long and strong cellulose fibres. These are required to be sub-divided into smaller units. They afford well to strong and long beating, whilst raw materials such as plantain fibre, straw etc., yield shorter and weaker cellulose fibres. In such cases the beating operation is limited simply to separte the individual fibres from their clusters. But beyond the separation of individual fibres they are not further reduced to small dimensions. These materials are also not useful for the production of a very strong and durable paper. In the case of such fibres even rubbing is sufficient to reduce them to pulp.

The implements used in beating the fibres to pulp are (1) A dhenki or stamper, (2) a mechanical stamper either worked by power or by hand or (3) an hollander beater.

(*i*) *Old type of Dhenki.* In olden times, and in villages even at present, the beating operation is carried on by a simple contrivance called the 'dhenki' or the stamper. It consists of a long wooden horizontal lever. The fulcrum which is almost in the middle of the lever rests on two pivots. To one end of the lever is attached vertically a cylindrical piece of wood, into the bottom of which are inserted iron hammers or beaters which rest on a peice of stone when the stammer or the dhenki is not working. The power is applied to the other end. In principle the dhenki is nothing but a mortar and pestle which is worked by a lever.

Figure No. 3 illustrates the general pounding arrangement. It consists of 3 main parts. 1 shows a rectangular trough made of either stone or cement concrete of brick and lime-mortar. It is 4 to 5 feet square and 2½ feet to 3 feet deep, a portion of it about 1 to 1½ feet being above the ground, and the rest underground. This underground portion is shown by hatched lines in the drawing. At the bottom of the trough is firmly imbedded a stone of the hardest description

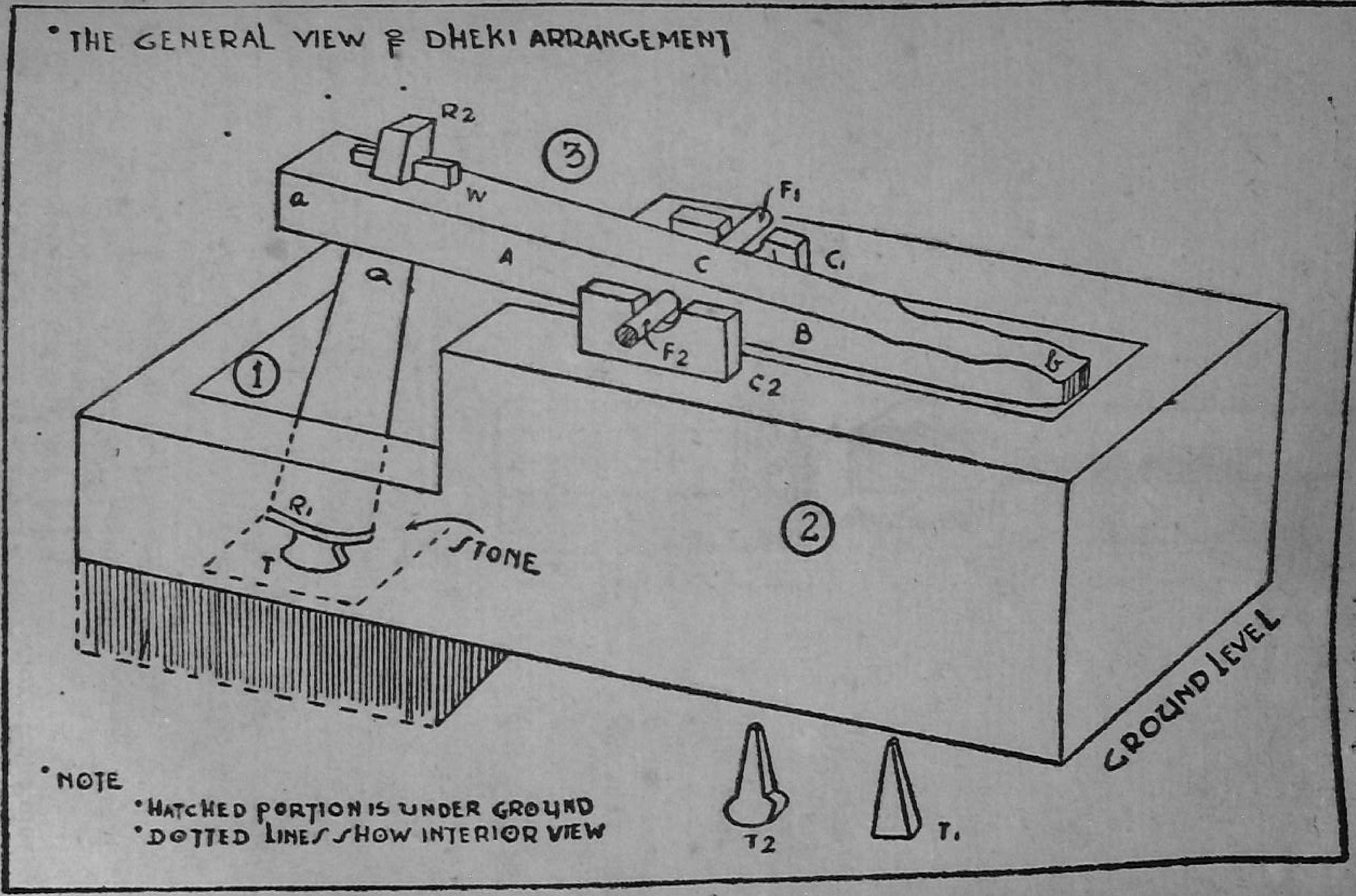

• THE GENERAL VIEW OF DHEKI ARRANGEMENT
R2
3
a
W
F1
A
C
C1
Q
F2
B
b
1
C2
R1
STONE
2
T
GROUND LEVEL
• NOTE
• HATCHED PORTION IS UNDER GROUND
• DOTTED LINES SHOW INTERIOR VIEW
T2
T1

Fig. 3

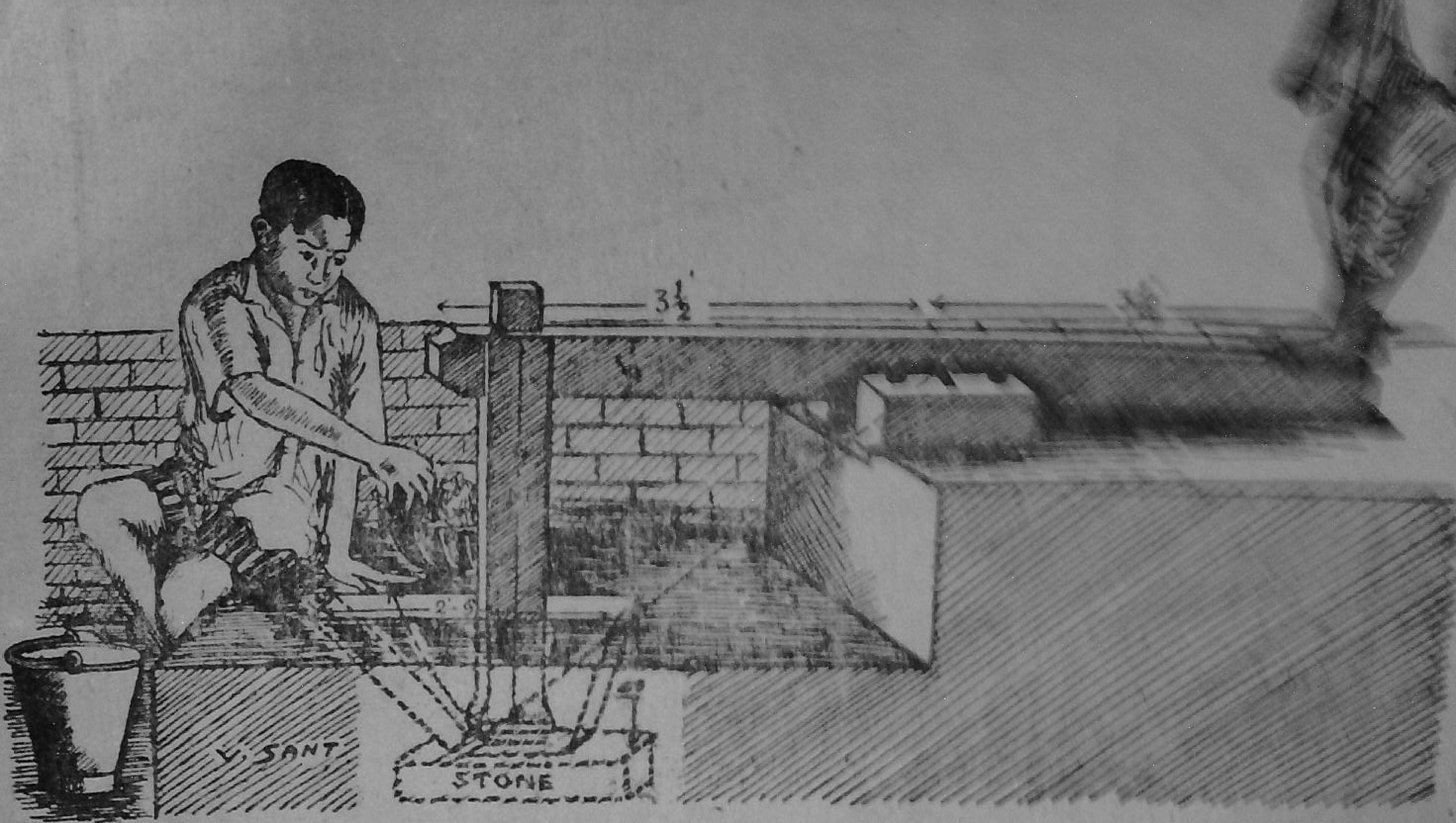


Fig. 3.A.—Modified Dhenki

either basalt or stone such as is found in river beds. It is about 2 feet long, 1½ feet broad and 1½ feet deep. The stone is shown in the illustration by dotted lines at the bottom of the cistern. The material is pounded over this stone. 2 is a raised platform about 2½ to 3 feet high, 4 to 5 feet broad and about 8 to 10 feet long. The central portion is made somewhat hollow for the free working of the dhenki lever. This raised platform is used for fixing the dhenki and also for the workers to stand on. It is made of mud with stone lining 3 represents the construction of the dhenki as described:— A B is lever or horizontal beam of wood 10 feet in length. At C about 4'5" from the lever end b is fulcrum F1 F2 passing at right angles to the lever. It rests on pivots C1 C2. These pivots are firmly fixed by means of three or four wedges in the platform on which they rest or they may be fixed by means of bolts and nuts into the floor. The beam at the stamping end a is 10" broad and 7" thick, while at the end b it is about 7" by 3" to 4" thick. At the pressing end b there are 2 or 3 notches where are workmen put one of their feet to press it. At Q *i.e.* about 3'6" to 4' from the fulcrum C is fixed a vertical cylindrical piece of wood R 1 R 2. The total height of this piece of wood between R1 and R2 is about 6'3" of which the cylindrical portion below the lever is about 5', or sufficient height so as not to strike against the head of the man sitting below.

This cylindrical beam or the stamper proper is firmly fixed into the lever by means of a wedge as shown at W. The circumference of the cylinder at R1 is about 42", while at Q close the lever it is about 30" to 32". The end at R1 is collared by an iron patti or band about 1" to 1½" broad and ½" thick. The iron teeth or hammers, generally four in number are insterted into the bottom of the cylindrical stamper RI R2 as shown at T. Each hammer is about 3½" × 2½" at its stamping end, 7" to 8" long and tapers at the top for inserting into the wood. The drawing shows only one face of the teeth. The hammers may be flat or slightly rounded at the bottom as shown at T1 and T2. They are firmly inserted into the stamping cylinder so that during the action of the dhenki none of them may become loose and cause trouble. They

project by about $2\frac{1}{2}$" outside the stamper and are all in a row parallel to each other, their lower stamping ends being in the same level. Each tooth weighs about 4 to 5 seers. They are so adjusted, to the stamper that when it falls over the material on the stone down below, the bottoms of the teeth are flat against the surface of the stone in the dhenki trough. The upper surface of the stone is flat and in level with the bottom of the trough. The dhenki illustrated is worked by 6 men. Even a small dhenki worked by 4 or 2 men may be constructed by reducing the dimensions of the wooden beams and with one or two teeth.

The action of the dhenki is as follows.—Six men place one of their feet on the notches shown at the end b of the dhenki and another foot on the raised platform which is generally made of stone or earth and press the dhenki. This causes the other end of the dhenki with the toothed wooden cylinder to rise up. Then they suddenly release their feet from the dhenki, when the pestle falls by its own weight over the pulp. A workman or two at the bottom of the cistern push the pulp under the teeth of the stamper to get it pounded. When the whole material has gone under the stamping cylinder it is worked back to its original position passing this time also under the stamper. The man who does this work has to be careful as his task is comparatively hazardous. Any slight inattention will result in his fingers or his hand being bruised or broken. The strokes are rapid and continuous.

By this mode of beating, the fibres are not cut but they are bruised and broken to small divisions of the ultimate fibres. The felting properties of the fibres are not injured, but on the contrary they are increased due to bruised ends. Naturally the paper made from such pulps is stronger than that made with machines. The old paper-makers followed and are still following in some places this process of beating.

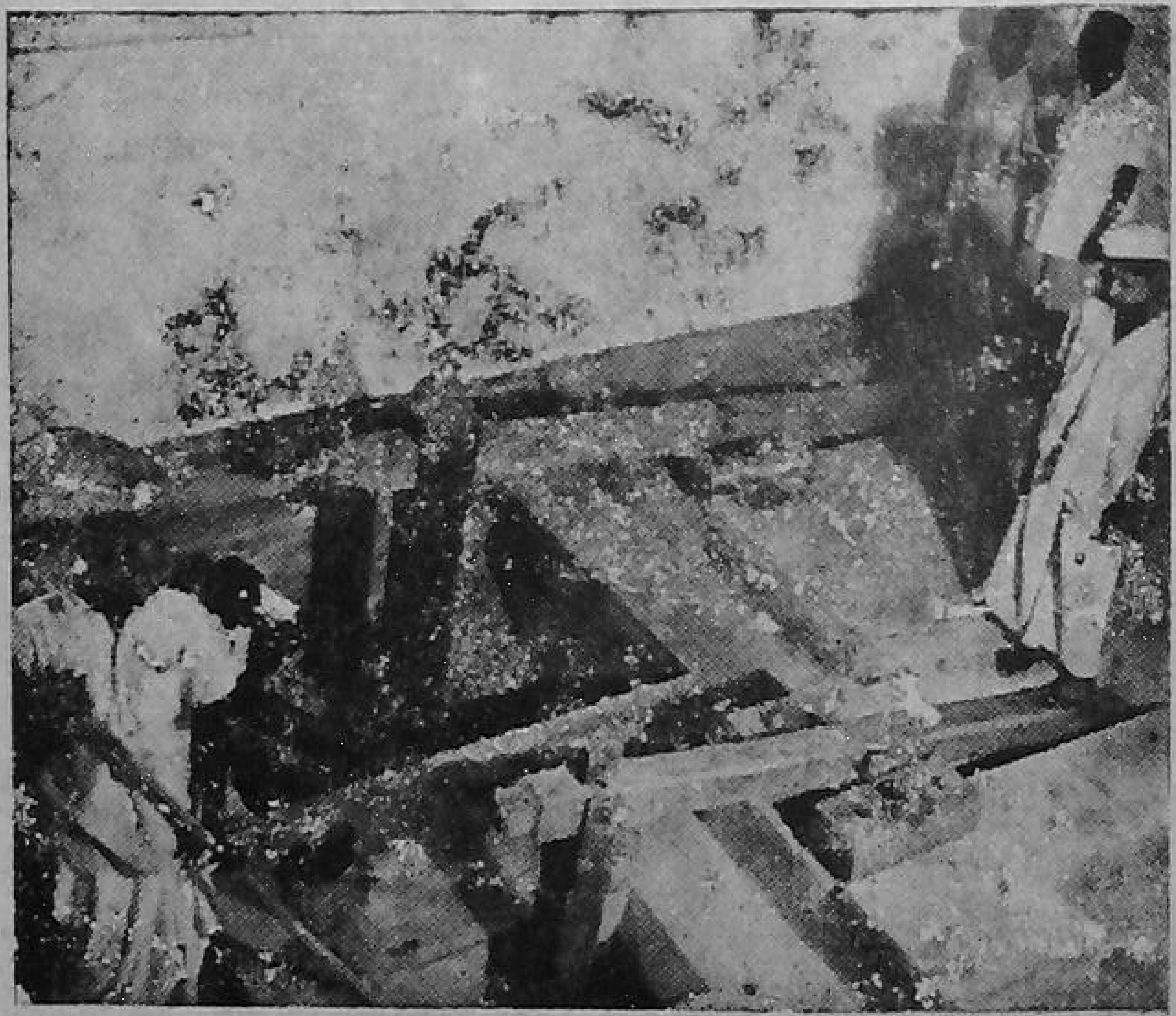
(*ii*) MODIFIED DHENKI.—In the old system of the dhenki the pulp-maker has to sit at the trough and push the pulp under the hammers of the dhenki. This is dangerous in that it is likely to cause injury to his fingers, which may sometimes prove serious.

In this new modified form all the essential parts of the dhenki are the same as in the old type except the trough which is made considerably smaller as well as shallower than that in the old system. See Fig 3-A. The trough in the illustration is 30" × 16" at the top and 8" × 7" at the bottom and is 18" vertically deep. The right and left sides of the walls slope equally towards the bottom, while the front and the back sides have peculiar slopes in that the former has a greater inclination in order that it may not obstruct the free movement of the pestle. A hard basalt stone is imbedded at the bottom so that the pestle rests centrally over it. The dimension of the dhenki in the illustration (Fig. 3-A) are—horizontal lever 7' × $4\frac{1}{2}$" × $4\frac{1}{2}$"; vertical rod 3' × 6" × 5". The axle is fixed in the middle of the horizontal lever. The number of teeth is one or two.

The dhenki and the trough may be consrtucted in any suitable sizes with the precautions that the depth of the trough is not greater than 18", the face of the bottom is slightly greater than that of the pestle, and the front side should not obstruct the free movement of the stamper.

The material to be pounded is put in small quantities at a time in the trough which is afterwards filled $\frac{1}{2}$ to $\frac{3}{4}$th with water in such a way that at its maximum lift, the pestle remains partially submerged in water. This prevents splashing of the pulps by the strokes of the dhenki which is worked as usual. The material is stirred by the strokes themselves and comes automatically under the action of the hammers. It may occasionally be stirred with a rod. When one lot is completely pulped it is removed and fresh one added. By this system the pulp-maker has only to watch the beating operation from outside the trough. Hence it is absolutely free from any danger of injury.

This has the same beating action as in the old system. It has also another advantage that no sooner a portion of the pulp is hammered, it immediately comes in contact with water so that the fibres are separted immediately insted of remaining in lumps. So also in contact with water the bruised fibres get hydrated.



Modified Dhenki and old Dhenki at work.

Plate 2.—Mechanical Stamper

In any system of the dhenki construction, the pestle of the stamping cylinder must be sufficiently heavy so as to bruise the fibres well.

(*iii*) MECHANICAL STAMPER.—It is a new from of dhenki, compact and more efficient and requires less space than the old dhenki. See plate no. 2.

Main Requirements.—1. Six wooden beams $5\frac{1}{2}' \times 5'' \times 4\frac{1}{2}''$ with sets of teeth or hammers fixed into the both ends of each one of them. 2. Two side posts $7' \times 6'' \times 5''$ each, fixed in a framework. 3. Four guide posts $3'6'' \times 3'' \times 2''$. 4. An hexagonal wooden cylinder 2' 6" long, each side of the regular hexagonal face being 4". 5. A piece of M. S. shafting 5' long and 2" in diameter, or square M.S. bar 5' long and 2" square turned at both ends. 6. Six rollers $2'' \times 2''$ diameter with central bore of 1". 7. Two bearings for 2" shafting. 8. One fly wheel or cart wheel to serve as fiy wheel. 9. A hard basalt stone $2\frac{1}{2}' \times 10'' \times 12''$. 10. A bottomless wooden trough $2\frac{3}{4}' \times 2' \times 2'$ deep, front and back sides sloping equally towards the bottom which is $2\frac{3}{4}' \times 8''$.

Construction. Two different sets of teeth are fixed into the tops and the bottoms of the stampers. On one side wooden blocks called "pins" $4\frac{1}{2}''$ and 3" square fixed are by means of iron brackets exactly in the middle of each of the stampers. The stampers rest between the side wooden pillars and the guide posts fixed into them by nuts and bolts, in such a way that each one moves freely up and down in its own position. The bottoms of these stampers lie on the hard basalt lava stone imbedded into the ground. The wooden trough lies over this stone in such a way that water or pulp does not leak through. Blocks of wood 3" square and $4\frac{1}{2}''$ high and tapering on the top from both side are fixed into the different faces at suitable positions on the hexagonal cylinder by means of iron brackets also tapered at the top. These blocks serve as 'cams.' In order to reduce the friction between the pins and the cams in their rotation, rollers $2'' \times 2''$ diameter are attached to these cams at the tops by means of steel bolts and nuts over which they rotate. The shaft, passing axially through the cylinder, rests in the two bearings on the frame

work attached to the side pillars. The fly wheel is attached at one end of the shaft. At the other end the drive is either taken on a pulley from a bullock gear or by a handle. Four men or two bullocks can easily work this stamper. The operation is as under :—The trough is half filled with water and 10 lbs. of the half stuff is put in and the stamper is started by turning the handle of the cam shaft. During its movement the cams engage the pins of the stampers and raise them alternately, and when they release the clutch on the pins during the rotation the stampers fall on the material one after another by gravitational force.

In case the material is to be washed the dirty water is removed by a siphon through a wire gauze sieve immersed into the stuff, fresh water being supplied from a pulp. The pulp is stirred automatically by the fall of the stampers one after another. This also keeps the material in circulation. However it is also occasionally stirred with a rod, as seen in the illustration, in order to prevent lump formation. Before the introduction of the Hollander beater into Europe at the close of the 17th century, stamping mills were used for pounding the rags into pulps. Each stamping mill consisted of several batteries of three or four stamps almost similar in construction to the old type dhenki. Each set of three or four stampers worked the pulp into the trough in the same manner as described under mechanical stamper. The pulp from one set of the stampers passed on to the next one and so on to get further and further reduced till finally it was of proper consistency. A stream of water was circulated through these basins. The dirty water escaped through horse hair sieve.

Each pair of stampers produced about 2½ to 3 lbs. of rag pulp in 24 hours, stampers being worked day and night. The stamping mill was worked by water power or by wind mills. (See frontispiece Paper, its history, sources and manufacture by H. A. Maddox.)

In any of these methods the beaten pulps have the same characteristics as described under modified dhenki.

Sorting

Cutting Raw Materials

CHAPTER VI

PRACTICAL PROCEDURE FOR PULP-MAKING

Mechanical appliances. (1) Kadba or grass cutter, (2) hooked knife, (3) axe, (4) plain knife, (5) block of wood, (6) screen as is used in winnowing grains and seeds, (7) washing arrangement—river or flowing stream; specially constructed washing basin, cradle type wire gauze basket, (8) chaddar or a piece of cloth, (9) retting and bleaching vats of cement concrete, or wooden tubs, (10) a rough floor or ota made of cement concrete or stone, (11) wire cloth sieves, (12) boiling vessels or tanks, (13) bhatti or furnace, (14) baskets and buckets, (15) trampling pits, dish-shaped with mouth 27" in diameter and bottom 12" deep. (16) Beating—A dhenki or a hollander beater. (See also unit no. 1, Chapter XIV infra).

General precautions. (1) Personal cleanliness and cleanly habits are of the utmost importance. (2) The material should not mix with or lie carelessly near sand, dirt or any foreign matter, which, once introduced into the material in any of the processes is difficult to remove, and finds its way into the finished product, making it unsightly and full of stains. (3) Feet should be washed or cleaned, and chappals or shoes should be kept outside or if necessary special ones kept for use in the factory. (4) All utensils and instruments, tubs and cisterns should be washed and cleaned after use. The floor should be given a periodic scrub. (5) Water used should be pure, clean, soft and plentiful. Stagnant or muddly water should not be used in any of the processes. The dirt or mud should be allowed to settle, and water having leaves, rubbish or pieces of wood floating in it should be filtered through a cloth or sieve. (6) Regularity and uniformity should be observed in each of the processes. (7) The premises should be stone-paved or made of cement or lime-mortar and concrete, so that there will be little chance of mud or dust nearby.

(*i*) PRELIMINARY TREATMENT: CUTTING, SORTING AND CLEANING. Cleaning, sorting and cutting are the preliminary processes in preparing the material for the subsequent treatment with chemicals. The raw material as it comes into the factory is not necessarily clean. It is likely to contain sand,

dust, mud, nails, wood stalks, etc. These are necessarily required to be removed, in as much as they are likely to spoil the paper. The cleaning can be done by thrashing the material against a charpoy or a wire gauze frame of 4 to 8 number mesh. By this, dust and other heavy metallic pieces are, removed. The process is somewhat the same as for winnowing grain. After cleaning, the material is also required to be sorted. The purpose of sorting is to remove materials other than that intended for treatment, even though the other materials may be useful for paper-making. In subsequent chapters it will be seen that different paper-making raw materials require different chemical treatments and different periods of beating. Hence, for pulp-making, only one uniform material should be taken. If the paper is intended to be made out of mixtures of different materials, then, the pulps of such materials are made separately and mixed together before sheet lifting.

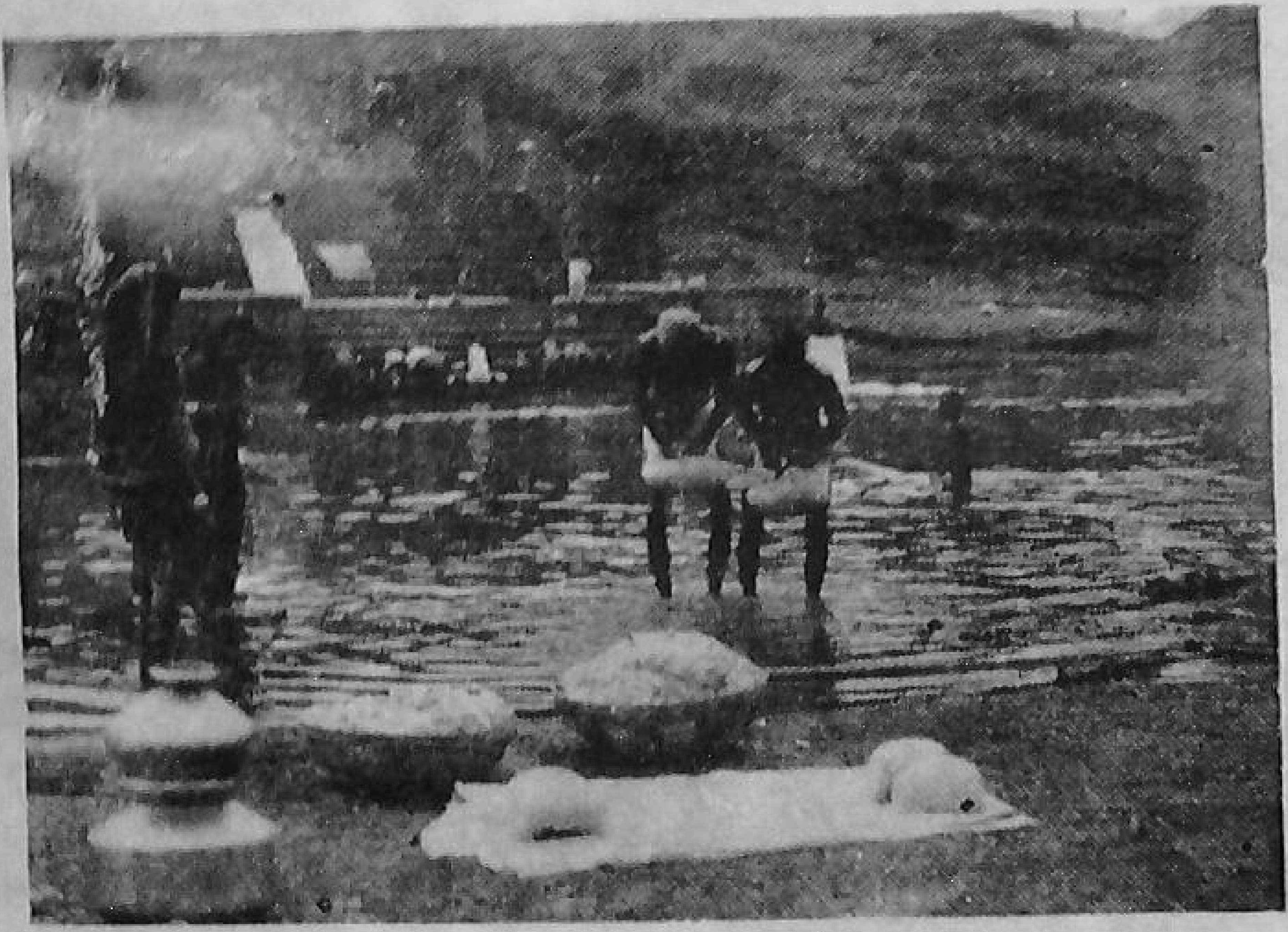
The cleaned and sorted material is then cut into small pieces of about 1" to 1½" length. They should not be cut too small as then the felting properties of cellulose fibres are destroyed making the paper weak. The instruments used in cutting are either a hatchet or an axe, or a knife hooked or crooked or straight, or a grass cutter and a block of wood. After cutting, the material is again cleaned to remove wooden and other particles, which may have incidentally got into it while cutting.

Soaking. The material after cutting is once wased to remove the adhering dirt, mud, etc., and soaked in cold water for a week or so, or in boiling or hot water for 2 to 3 hours at the end of which it is again washed. This removes the water-soluble non-cellulose matters from the fibre. Or whenever possible the material may be soaked for some days in the spent alkaline lyes from a previously treated material. These spent lyes should not be too dark. It is advantageous to lightly beat the material before soaking or washing as thereby the removal of the dissolved matters is better effected, so also the fibres are somewhat separated. The object of all these operations is to economise the use of the alkalis in the

Washing near the well.

River washing 1st stage.
Putting the pulp into the chadder

River washing 2nd stage
Washing the pulp in the midst of stream.



River washing 3rd stage.
After washing, the water is squeezed out.
Balls of the washed pulp on the chadder

subsequent chemical treatment. Moreover this soaking operation somewhat softens the material, whereby the alkaline action on the non-cellulose matters is better effected.

Washing. The object of washing is to remove the soluble impurities from the several operations in the process of pulp-making. As a rule the washing operation is performed after each process or treatment in pulp-making. The water must be clean, soft and plenty. This washing can be done by placing the material in bamboo baskets sometimes covered with a piece of cloth and pouring water over it, or by immersing the baskets partially in the flowing river or stream and sprinkling water over it. It can also be washed in a coarse cloth the ends of which are tied round the waists of two men standing apart and opposite each other. The pulp is put in the cloth which is partially immersed with its contents in water, and the two men to whose waists the cloth is tied, work the pulp to and fro, with their right hands, holding the cloth, with their left or sometimes with both hands. This is usually done in a river or tank or by the side of a well in which case water is poured over the pulp.

A convenient way of washing the pulp is in a rectangular basin or trough $2\frac{1}{2}$ to 3 feet long, 2 feet broad and $1\frac{1}{2}$ feet deep, which may be constructed of wood, or brick and lime-mortar, or cement concrete. A false bottom is made at a distance of about 4 to 6 inches from the real bottom. This may be constructed with split bomboo or may be a wire gauze frame closely fitting the sides of the basin. A piece of cloth is placed over this false bottom. The pulp is spread over this piece of cloth and water is poured over it either from a tap or from buckets till the pulp is quite immersed in it or till the basin is three-fourths filled with water. The pulp is well stirred and the dirty water drained off by opening the cock of the outlet valve at the true bottom of the basin.

A cradle type wire gauze basket may also be used for washing the pulps.

The washing can also be done conveniently by a drum washer as described under hollander beater.

(*ii*) Chemical Treatment.—After this preliminary treatment the material is treated chemically for removing the

non-cellulose matter of the fibres. This may be done in three ways: (1) retting or cold process, (2) boiling, and (3) combination of retting and boiling.

(1) THE RETTING PROCESS : LIME TREATMENT.

The material obtained after soaking and washing is mixed with a paste of slaked lime in the proportion of 100 parts of the fibrous material orginally taken to 10 to 15 parts of dry quicklime (slaked with water before using). The material should be thoroughly and uniformly mixed with the lime paste and kept overnight in a tank or trough of suitable dimensions. Next day it should be pounded lightly under the dhenki to loosen the fibres and mix them well with lime. It should then be kept either it kundis (troughs) or on the ota (floor) in a heap. The upper surface gets dry by evaporation, hence some water should be occasionally sprinkled over it. The material should also be stirred from time to time so that fresh surface is exposed to light and air. If possible the mixture should get sunlight as this helps chemical reaction between the alkalis (lime, soda, caustic soda etc.) and the non-cellulose matter. The sunlight has also a bleaching action on the material. It is kept in this condition for a week to a fortnight or even for a month.

Note:—When available the quicklime used should be of good quality *i.e.* should contain the maximum amount of calcium oxide, and must be free from coloured earth, grit or unacted limestone. The test for good lime is that when it is mixed with water it will swell with the generation of heat resulting in steam coming out of it.

At the end of the required period the material should be treated under the dhenki and washed. This treatment will remove impurities better.

Soda treatment.—The material which is completely washed after the lime treatment is next treated with a mixture of soda ash, papadkhar, or sajjikhar and lime, or caustic soda alone.

If caustic soda is used it should be about 7½ to 10% of the material taken. It should be dissolved in water and mixed with the material.

If soda ash or papadkhar and lime are used the proportion of soda to lime should be about 100 parts of soda ash to 75 parts of quicklime. Theoretically 106 parts of soda ash require 56 parts of quicklime for causticization but as quicklime is not always hundred percent pure, the proportion to be used should be 1 part of soda ash or papadhkar and $\frac{3}{4}$ parts of quicklime. The mixture should be thoroughly powdered.

The percentage of such mixture to be used for treating is between 15 to 20% in the case of soda ash or 20 to 25% in the case of papadkhar of the weight of the material taken. It should be thoroughly mixed with the material, some water being added if necessary.

If sajjikhar and quicklime are to be used, they should be taken in the proportion of 4 parts of sajji to one part of quicklime, and mixed. Of such mixture, the proportions for the treatment of the material should be 100 parts of the material originally taken and 30 to 40 parts of sajji lime mixture. These should be thoroughly mixed together.

Note :—The mixture of soda or sajjikhar or papadkhar with lime ultimately produce caustic soda. Therefore the action of such mixture on the raw materials is exactly the same as when caustic soda is used for the treatment. Sajjikhar and papadkhar are impure carbonates of Soda. The percentage of actual carbonate of soda varies in different samples. There are also other salts present in sajjikhar, so the proportion should generally be taken as above.

After sufficient time, say a week to a fortnight, the material should be given a dhenki treatment and washed. Whichever of the above chemical processes is followed, the subsequent treatment is the same.

Repetition of soda treatment. If the material is not sufficiently reduced, the soda treatment should be repeated till the material is reduced to a homogeneous pulp with the removal of the non-cellulose matter. The dhenki treatment may be repeated at intervals during the retting of the material, thereby minimizing the retting time, as well as helping better

penetration of the chemicals. If possible the material should be exposed to sunlight and air but should be kept free from dust etc. The number of treatments depends upon the impurities and the form in which the fibrous materials are taken for treatment. Materials which have been in constant use such as ropes, baskets, etc., which are worn out and become old, may require less treatment. Also, the dhenki treatment depends upon the quality of the paper to be produced. For finer paper, more and coarser paper, less treatment may be given. The retting process generally takes from one to three months before the pulp is ready for paper lifting.

(2) Boiling or digestion. If the retting process is not followed, then the material should be boiled or digested with lime or any of the other chemicals mentioned above using the same proportions, with the difference that there should be plenty of water to boil the material with the chemicals. Each boiling should be conducted for about 6 to 8 hours. The vessels used should be either of iron or copper and must have capacity at least $1\frac{1}{2}$ times the volume occupied by the material should be thoroughly washed and given a dhenki treatment. See description under open boiling and digestion systems, in Chapter V.

(3) A combination of retting and boiling may be given in certain cases to reduce the time required for pulping. This may be sometimes more economic also. The advantages of such treatment have been described in Chapter V.

See also notes on blotting and filter paper, Chapter XII.

Note :—The retting process is the cheapest; only it takes a very long time to make the proper pulp. Boiling or digestion, on the contrary, is the quickest but at the same time may be a costly method, depending on the cost of fuel. Wherever light fuel such as rubbish, dried leaves and branches of shrubs are available, this cost may be negligible. The boiling, digestion or retting process may be repeated according to requirements, for the removal of the non-cellulose matter. For

instance, bamboo is required to be digested twice. (See under bamboo as a raw material in the next Chapter.)

Bleaching.—There are two methods of bleaching : (*a*) sun bleaching and (*b*) chemical bleaching.

(*a*) SUN BLEACHING: The material in the retting or boiling process should be exposed to sunlight and air, the combined action of which bleaches it. It should be moistened with water and spread out occasionally on a stone or cement floor or mats of close texture for some days during or after the chemical treatments. Sun bleaching is not so efficient but there is no chance of deteriorating the cellulose as in chemical bleaching.

(*b*) CHEMICAL BLEACHING : The bleaching agent generally used and easily available is bleaching powder (calcium hypochlorite).

Bleaching powder :—The oxidizing *i.e.*, bleaching agent, chlorine, available in ordinary bleaching powder, is generally 30 to 35%. The powder is required to be kept tightly closed in vessels preferably of porcelain or glass. If the packing is original, say 1 cwt. or 3 cwt. drum, it should be opened carefully and the lid placed tightly after taking out the required quantity of the powder. Bleaching powder deteriorates in course of time if exposed to air, especially in moist or monsoon weather when the powder absorbs moisture and becomes wet and rapidly loses its bleaching quality.

Commercial bleaching powder is not completely soluble in water. Hence while making solution there remain insoluble residues mixed with water containing the active bleaching agent. Unless this is recovered it goes to waste if it is thrown away. This is an economic loss. To prevent this loss the residues are extracted two or three times with small quantities of water each time by which all the active bleaching agent is recovered. All the extracts are collected and mixed together. In order that the solution may not be too weak, the quantity of water added should be small each time. If bleaching powder is added to water the lumps are not properly dissolved as they remain without breaking even after considerable agitation. Hence the solution should be made as follows :—

Making solution of bleaching powder. The requisite amount of the powder having been taken is put into a small wooden tub or bucket. Any lumps are broken to powder by light strokes with a piece of wood. The powder is mixed with a small quantity of water and stirred with a piece of bamboo to a homogeneous paste. This should then be mixed with some more water and allowed to settle, after which the clear liquid should be strained through a wire gauze or cloth. To the sediment in the vessel some more water should be added and after allowing the former to settle, the clear liquid should be strained and mixed with what was obtained with the first straining. The process should be repeated a third time. Generally the strengh of the bleaching powder solution should be kept 4 to 5% *i.e.*, 4 to 5 lbs. of powder in 10 gallons or 100 lbs. of water. The following example will illustrate how to make a solution. Supposing for 80 lbs. of rags one wants to use 5% bleaching powder, what one has to do is to calculate the amount of the bleaching powder required. Thus $5 \times 80/100 = 4$ lbs. of bleaching powder is required. If the solution is to be made of 3% strengh *i.e.*, 3 lbs. of bleaching powder in 10 gallons of water we have to take $4 \times 10/3 = 13$ gallons of water. Now, to make a solution from 4 lbs. of bleaching powder mix the powder with about a gallon of water and with a bamboo or wooden stick make a thorough paste without any lumps. Pour into it about 5 gallons of water and stir with a bamboo and keep it at rest for some time till the residue subsides and then gently drain the clear liquid through cloth without disturbing the sediment. To the residue add about 4 gallons of water and stir and allow it to subside. Drain the clear liquid as before through cloth into the solution obtained with the first straining. Again mix the residue with another 3 gallons or the remainder of the water and drain as before and mix it with previous extracts. The total solution will represent about 4 lbs. of bleaching powder in about 13 gallons of water. The residue is useless and should be rejected.

In order to ascertain whether the active bleaching agent (calcium hypochlorite) has been completely removed from the residues of bleaching powder, the following test may be performed.—Take a small crystal of potassium iodide and

dissolve it into a very small quantity of thin starch paste. Dip small strips of unsized white paper into this mixture and dry them. Insert one such piece into the bleaching powder residue after it is extracted three or four times. Place a small drop of dilute hydrochloric acid or lemon juice over the strip. If the strip becomes blue then it indicates that all the bleaching agent has not been completely removed from the powder. The residue should be extracted once or twice with a small quantity of water, each time testing the subsequent residue with starch-iodide paper as before. When the bleaching powder is completely exhausted of its active agent then it does not give blue colour with the test paper. If the test paper shows a very faint colour then the residue may not be further extracted and mixed with the previous extracts as thereby the solution will be weaker. If at all the residue is extracted it may be used for dissolving fresh bleaching powder for another operation.

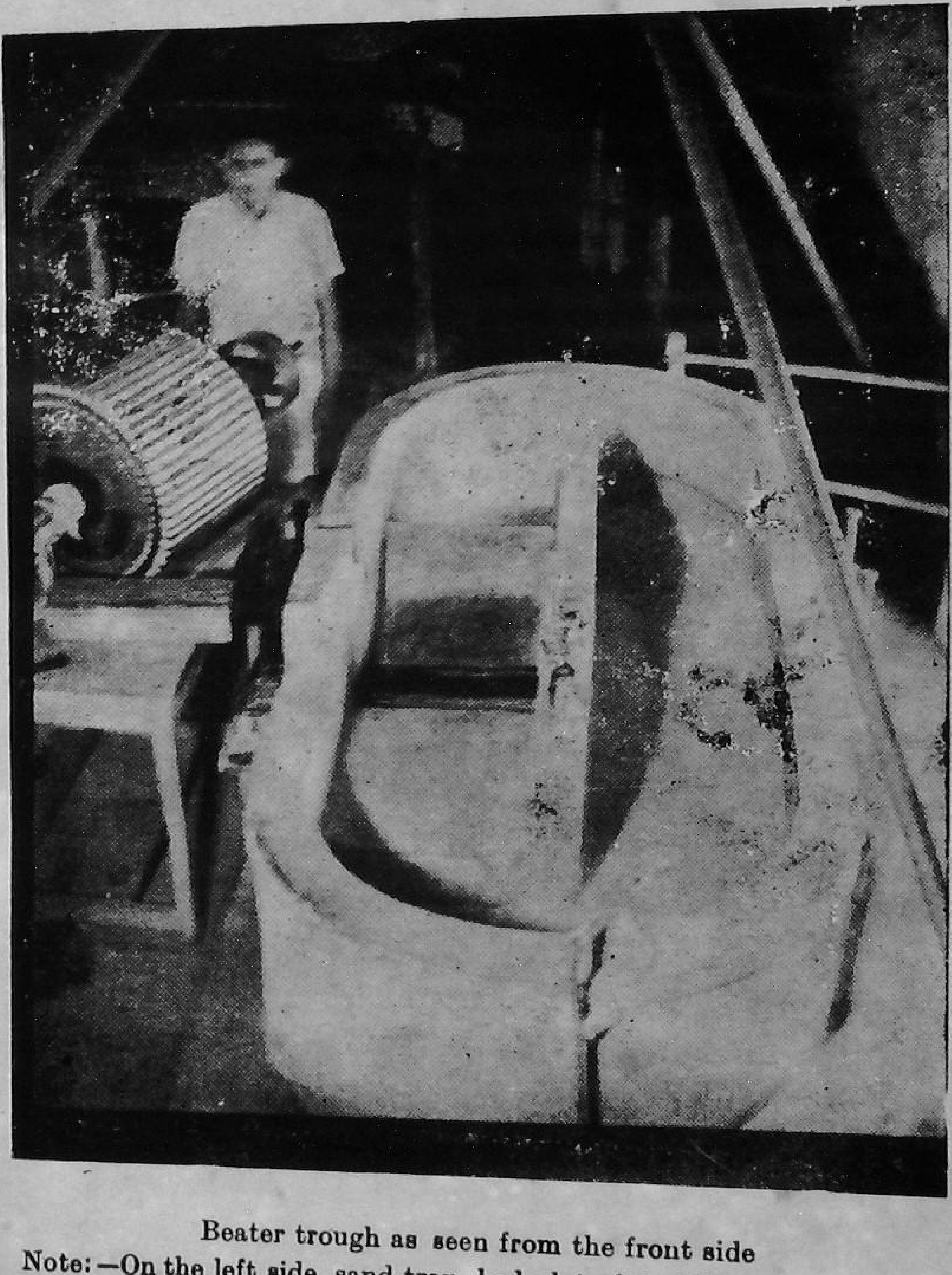
Bleaching powder contains some free lime which is also dissolved by water in making solutions. The presence of such free lime in the bleaching solutions retards the chemical action. Hence also the total quantity of water used for dissolving the bleaching powder should not be too great as thereby the proportion of free lime to chlorine in the bleaching solution will be greater which is disadvantageous. It is always preferable to make fairly concentrated soultion without sacrificing the available chlorine in the bleaching powder.

The amount of the bleaching powder required varies with the nature of the material. Thus cotton rags require 3 to 5 per cent according as the rags are bleached or unbleached. Gunny wastes require 10 to 15 per cent for obtaining half bleached pulp. They should never be bleached full. Plantain fibre consumes about 20 to 25 per cent, white paper wastes require about 2 to 3 per cent, sunn-hemp about 6 to 8 per cent. Grasses are bleached with 12 to 15 per cent of the powder. The bleaching powder required also depends upon the degree of the removal of the non-cellulose matters in the previous alkaline treatments.

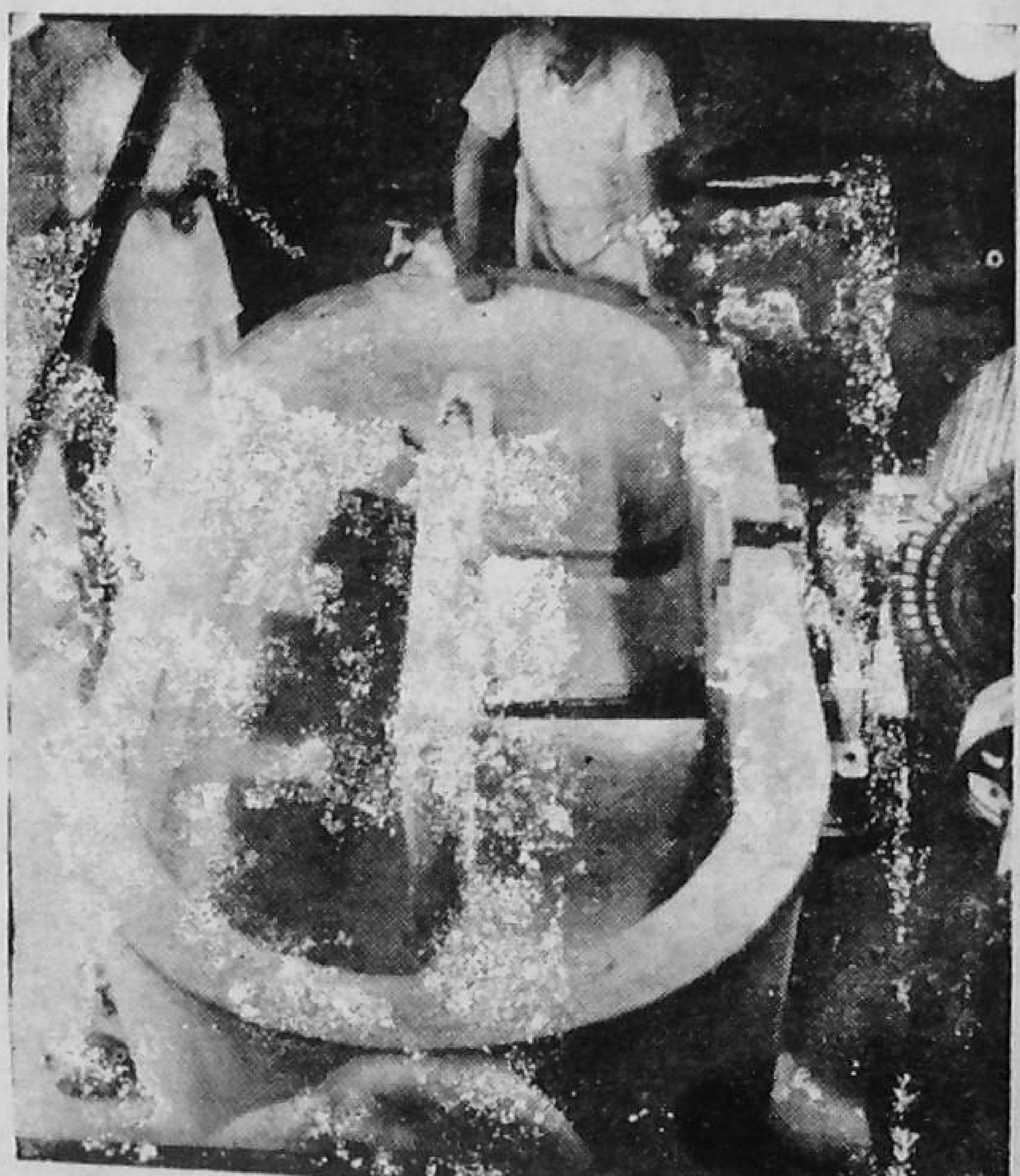
Bleaching the pulp:—The requisite amount of the bleaching solution having been made it should be mixed into the wet

pulp. The time taken for the action of the bleaching solution on the pulp is about 12 to 24 hours. The main action of the solution is on the residual non-cellulose and colouring matters and not on the cellulose itself, provided the solution of the bleaching agent is not strong or the quantity of the bleaching powder is not far in excess of the requirement. For storing the solutions and bleaching the pulps, metal vessels should not be used as they are attacked by the chemical. This is also likely to discolour the paper. This is true especially when iron vessels are employed. Aluminium vessels are attacked very readily, holes being made in them. Hence only wooden tubs, enamelled vessels, or troughs of cement concrete or stone should be used. Ordinary buckets may be used for dissolving the powder or pouring the solution into the pulp, but they should be immediately cleaned and thoroughly washed. On no account should bleaching solution be stored in ordinary buckets.

The mixture of the pulp with the bleaching solution should be stirred well in order that the action of the solution may be uniform throughout the mass. During the first few hours the action is rather rapid, so the pulp should be stirred well at an interval of half to three-fourths of an hour and then of one or two hours, as otherwise the bleaching will not be uniform. Another plan is to bleach the material in a wooden cask. After adding the solution to the pulp the cask should be covered tightly with the lid so that no liquid comes out. The cask should be turned down and rolled to and fro, so that the action will be uniform. The pulp in the bleaching solution should be immersed completely leaving some liquid over it, otherewise it will get spoilt in contact with air. Lumps of the bleaching powder should never be allowed to get mixed up with the pulp, for, the pulp surrounding it will be spoilt, thereby weakening the paper. To prevent this, the bleaching solution should be strained through a piece of cloth or a sieve. Materials requiring more of bleaching powder should be treated twice or three times with the bleaching solution, but on no account should it be very strong. If the pulp is bleached twice, it is advisable to wash the material



Beater trough as seen from the front side
Note:—On the left side, sand trap, bed plate & inside of the back-fall



Beater trough as seen from the back side.
Note:—On the right side, slope of the back-fall, bed plate & sand trap.

after the first bleach to remove as much of the dissolved impurities as possible. This facilitates subsequent bleaching. If the pulp or half stuff as it is sometimes called before final beating, shows no signs of appreciable bleaching in the first operation, then after washing, it may be boiled with 1 to 2 per cent caustic soda on the weight of the original dry fibre. This helps in removing more of the non-cellulose matters. After washing the final bleach may be given.

It is necessary to give sufficient time for the action of the solution on the pulp. So also it must be born in mind that the dilution of the pulp with water should not be too great as in that case the concentration of the bleaching agent in the mixture will be too low making the action too slow. Generally the quantity of the water should be such that the pulp in the mixture can be stirred easily with a wooden stick. In order to reduce the quantity of water, the pulps may be squeezed before adding bleaching solution.

Wherever a hollander beater is constructed the bleaching operation may conveniently be performed in it. For better results it is a good plan to add the bleaching solution after the half stuff is partially reduced to such a condition that the individual fibres are separated from the clumps but are not reduced to sub-division by advanced beating, in the beater or the dhenki.

By the ordinary way of boiling or retting the material, it is not always possible to obtain perfectly bleached white pulp from all the materials. Some may give white pulp, others may not. In such cases it is no use attempting to make perfectly bleached white pulp, as it will be costly and difficult with the ordinary method of simple boiling and retting of the fibrous materials in alkali. Such materials require boiling with alkalis or some other chemicals under high pressure and temparature to remove the hard non-cellulose matter and to produce white pulp eventually. This may not be possible in villages.

Note:—By the directions we have given for making the bleaching powder solution of definite strength we simply mean that the stock solution should be of that strength. When the solution is added to

the wet pulp its actual strength in the mixture will of course be less and still less when additional water is added to keep the pulp ? immersed. After the bleaching treatment the pulp should be washed thoroughly otherwise it will get spoilt.

Antichlor. When the pulp is bleached chemically, even after through washing there is a possibility of some traces of the bleaching agent remaining in the pulp which is harmful as the chlorine from the bleaching agent oxidizes the cellulose in the paper, making it weak and brittle in course of time. This is also the reason of the deterioration of the books printed on some varieties of machine-made paper. Sometimes to economize time, water and also power, the pulps are not washed with water in cheaper grades of paper. This residual chlorine is removed by sodium sulphite or hypo, using a very small quantity of either of the chemicals. The pulp should be mixed with the chemical previously dissolved in sufficient water and kept for some time, say about ½ to 1 hour and washed well.

(*iii*) *Beating.*—The implements used for beating are (1) A Dhenki, (2) A Mechanical stamper, (3) A Hollander beater. The first two are described in Chapter V.

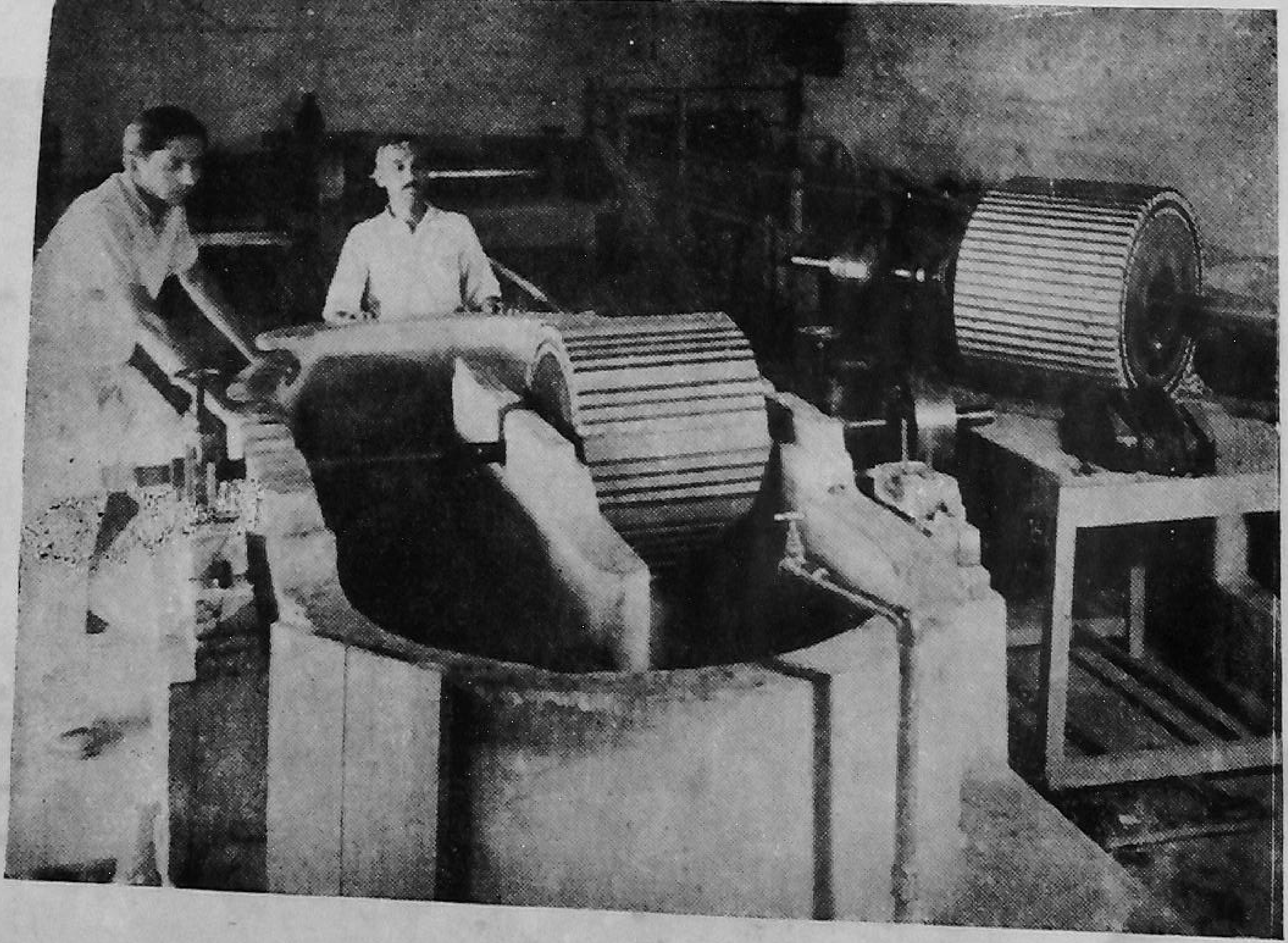
Hollander Beater.

In modern practice the dhenki has given place to a very convenient apparatus called hollander beater. The different parts of the apparatus are:

(1) A trough
(2) A roll
(3) A bed plate
(4) A hood with doctor for the roll
(5) A washing drum

For details see Fig. 4 and 4-A and plates 3, 4, 5.

1. THE TROUGH. The trough T consists of an oblong vessel having semi-circular ends, the remaining sides being parallel to each other. The partition wall P called "Mid-feather" lies exactly in the middle of the trough so as to form a continuous channel of 1' 6" width around it. The trough is constructed on a rectangular solid masonry plat-



Beater trough with roll on

Plate 3.—Beater view from bed plate

form 9' x 5' x 1' high. The outer dimensions of the trough proper are 8' 7" x 4' 3" x 2' 3" and 1' 9" high at the back and the front respectively. The mid-partition P, 4' 9" long, corresponds with the side walls of the trough in heights. The walls of the trough and the mid-feather are 5" thick and made either of r. c. c. or brick work with cement plaster. The bottom of the trough is 16" deep and dish-shaped. It slopes gradually from the back-fall F towards the drum-washer W, as far as the drain pipe and then gradually rises from the sand-pit with a higher gradient as far as the bed plate compartment B. The sand-pit 1' 6" x 3" x 1" deep serves to entrap sand, nails and other heavy impurities. Exactly under the roll R and centrally located to it, is a hollow compartment 1½' x 8" x 6" deep, for fixing the bed-plate. At this portion there is an outside door in the trough T through which bed-plate B may be inserted under the roll R. This door is closed by a wooden board with rubber or other packing inside and is tightened by bolts fixed into the trough round the bed-plate compartment. See plate 3.

Immediately after the bed-plate compartment, there is the back-fall F behind the roll. It is constructed of cement concrete or wood having an outside slope and an inside curvature parrallel to that of R, the distance between this curvature and the roll bars being ¾". The mouth is wide *i.e.*, about 1". Pulp propelled by the roll flows over this back-fall. The top of the back-fall is somewhat higher than the axis of the roll by about 2".

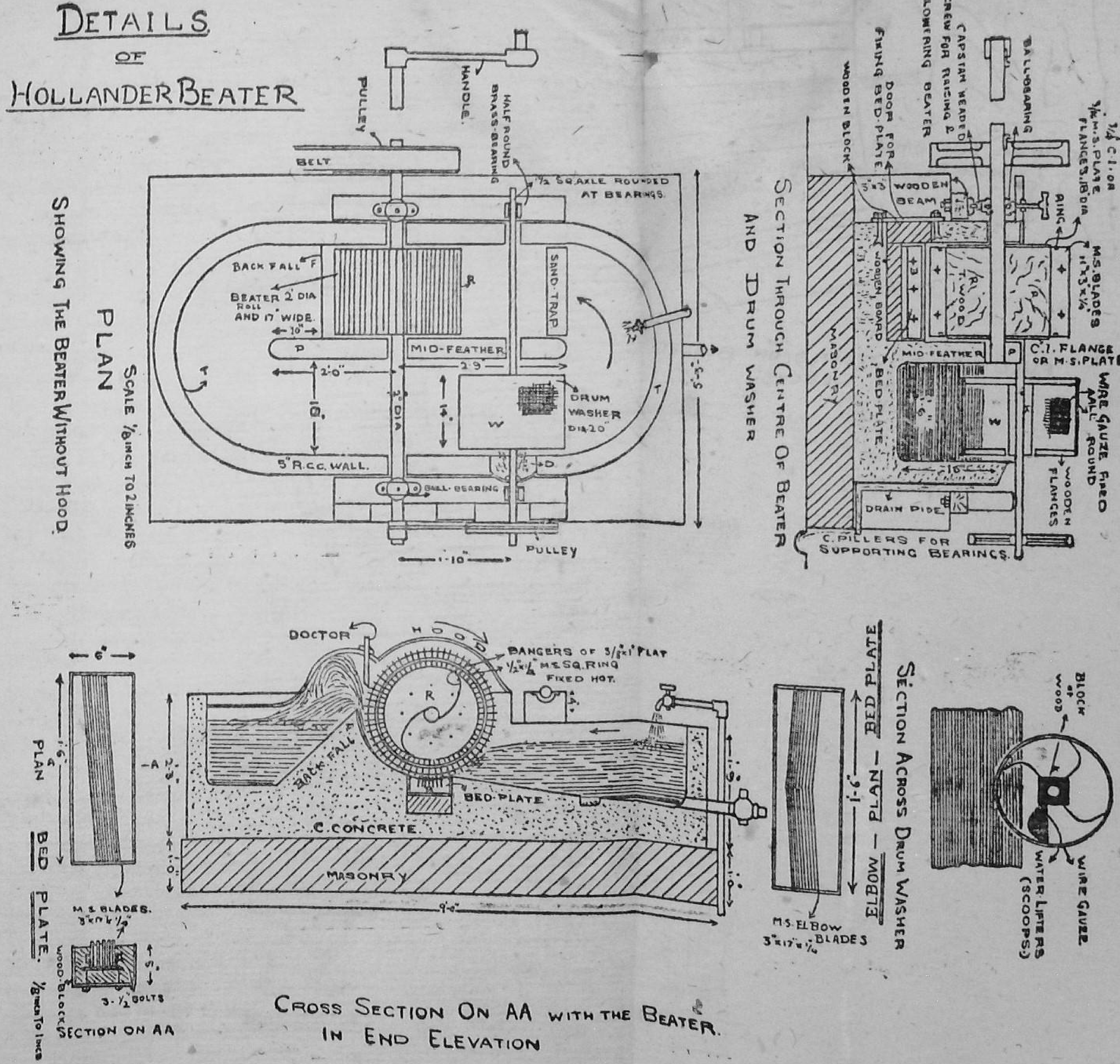
2. Roll. The requirements of the roll are: (1) One M. S. shafting 7' long and 2½" in diameter or a square bar 7' long and 2½" square turned at both ends at the portions of the bearings and pullies. (2) Two cast iron flanges or M. S. plate discs of 18" diameter and 1" thick with 2½" bore at the centre. (3) One wooden cylinder of 18" diameter and 15" wide with 2½" bore at the centre. (4) Sixty mild steel or steel blades each 17" x 3" x ¼" thick and champered to have 3/16" face on one side. (5) Sixty wooden wedges 17" x 2¼" x 1" thick properly shaped and tapered for fixing

over the foundation drum. (6) Two iron rings slightly less than 20" in diameter and ½" square. (7) Two special pedestals with 2½" brass or ball bearings with capstan headed screw and pressing wheel.

The construction is as under :

At a distance of 2' 3" from one end of the shaft, a foundation roll is prepared with the two discs screwed into the wooden cylinder, forming one whole solid drum 17" wide and 18" in diameter. This foundation drum is made firm by means of keys into the shaft so that it does not slip or slide over it. Half inch square slots are made at the ends of the wooden wedger and the blades at a distance of one inch from the lower edge. Each blade is now screwed into the wooden wedge by two countersunk wood-screws. These are then assembled over the foundation drum in proper positions by means of wood-screws passing through the wedges and the foundation drum. The two iron rings made red hot are now inserted into the circular channel formed by theslots in the wedges and blades at the two faces. They are immediatley cooled by pouring cold water over them. For details of fixtures of blades and wedges see Fig. 4 A. These rings serve to hold the blades tight over the foundation drum. Besides the screws, the wooden wedges swelling in contact with water exert pressure on the blades holding them firmly against one another over the drum. This completes the construction of beater roll whose dimensions are now 17" in width and 24" in diameter. Each blade must be parallel and equi-distant to the axis of the roll. This can be done by turning the finished roll on a lathe to make it true, or in the alternative by chipping off the untrue portion from the blades.

In the system described above all the blades are fixed at an equal distance from each other. There is another system in which the blades are fixed in sets of 3 or 4 blades in each one of them. The number of wedges in such set is lessor by one than that of the blades. The wedge between each consecutive set is somewhat greater than the wedges used in the blades *i. e.*, the distance between the consecutive sets is somewhat greater than the distance between the consecutive blades in the set.



Fig, 4—Details of Hollander Beater

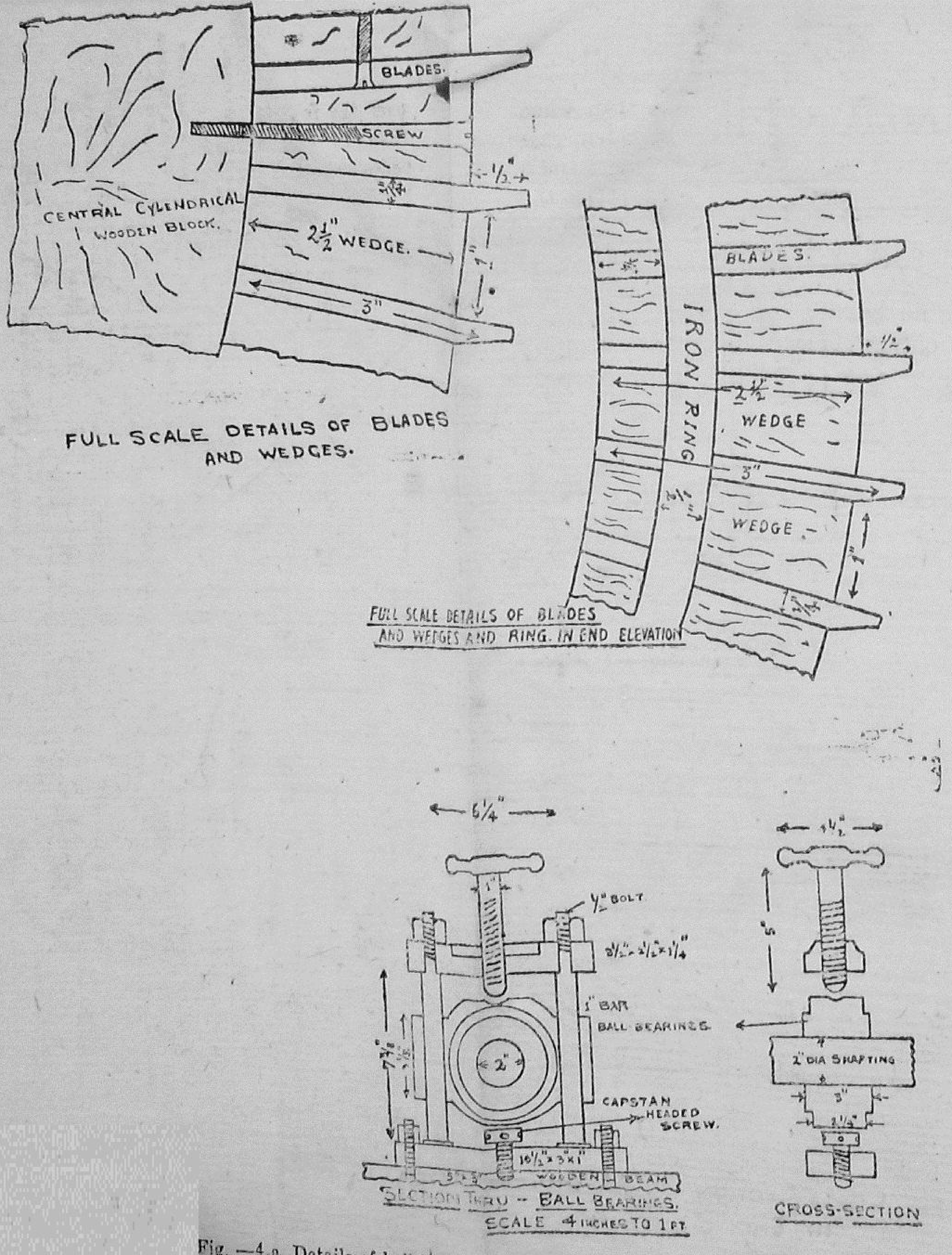


Fig. —4.a. Details of ball bearings and wedges of the beater roll

The total number of the blades is somewhat lesser than when they are fixed equi-distant to each other. In the present case 56 blades divided into 14 sets, each one having 4 blades and 3 wedges in it are fixed over the drum in such a way that the distance between each set at the outer-edge is $1\frac{1}{2}$." The shape of the wedges between the sets may be determined from the actual drawings.

It was a supposition that by this system the material is propelled better, but experience shows hardly any justification for this theory especially in the case of small beaters.

The blades in either of these systems are fixed radially towards the axis *e. g.* if the lines are produced in the direction of their fixtures they meet towards the central line. The blades in any of these systems project by about $\frac{1}{2}$" to $\frac{3}{4}$" over the wedges in the case of small beaters. When the beater is at work, some portion of the pulp is carried forward. This sometimes fall on the sides between the walls and the face of the roll with the result that the beater gets choked up. This is prevented by fixing 3/8" thick bars curved in the direction opposite to that of the rotation of the roll. These bars are called bangers (See fig. 4 cross section.) They prevent the lodgement of the pulps between the roll and the walls. The bangers must not obstruct the free movement of the roll. The clearance between the bangers and the walls should be between $\frac{1}{8}$ to $\frac{1}{4}$ of an inch.

The roll rests in two special journals with ordinary brass or ball bearings (for detailes see fig. 4 A.) in suitable positions outside the trough. The journal can be raised or lowered by turning the capstan headed screws, simultaneously raising or lowering the beater along with them. The wheel screws at the top, only serve to press down the roll with the bearings. After pressing, they should be raised up so that the bearings will be free to slide in the guide bars which hold them. This is necessary in view of the fact that sometimes rags or other materials rush suddenly in greater concentration or in lumps between the bed plate and the roll in which case the beater roll must be free to rise up as otherwise it would get jammed and stop rotating which is sometimes likely to result in the breakage

of the machine. The number of revolutions required by the roll is about 250 to 300 per minute. Generally the roll must make about 2000' circumferencial movement per minute. The number of revolutions of beater roll of any size can be calculated by dividing 2,000 by the circumference of the roll. Thus for a beater roll of 30" diameter and 24" width the number of r. p. m. = 2000/2½ x 22/7 or about 250. The beater roll must be sufficiently heavy, weighing at least 8 to 10 maunds in the case of small beater described in this book, so that it will exert sufficient pressure on the material. The beater roll must always be set true to the level bottle, as otherwise the blades will wear out unequally.

3. BED-PLATE. *Requirements*—(1) 5 mild steel blades 17" x 3" x ¼" thick. (2) 4 spacers of M.S. plates 17" x 2½" x ⅜". (3) a block of wood 18" x 6" x 2".

The five mild steel blades are camphered and assembled alternately with the spacer plates and are fixed by means of two half-inch bolts. These M. S. plates serve as spacers between the knives or blades. This set is now embedded into the wooden block at an angle of 5 degrees and wooden wedges 2" thick and of suitable shape are screwed into the block of wood so as to secure the set of blades firmly in between them. The bed plate is now put on the lathe and turned so as to have the same curvature as that of the outer surface of the beater roll or the blades may be chiselled out to have the proper curvature.

Bed-plates can also be prepared by using elbow blades and spacer plates instead of straight ones, in which case it is not necessary to fix them at an angle.

The object of keeping the bed-plate blades at an angle to the axis of the roll is to prevent the blades of the roll finding their way into the bed-plate which may cause injury to the machinery. If the blades of the bed-plate make a greater angle to the blades of the rotor, then they will have a scissoring action upon the material which is injurious to the pulps intended for strong papers, although it may be beneficial for the production of weaker papers such as blottings, filter-papers etc.

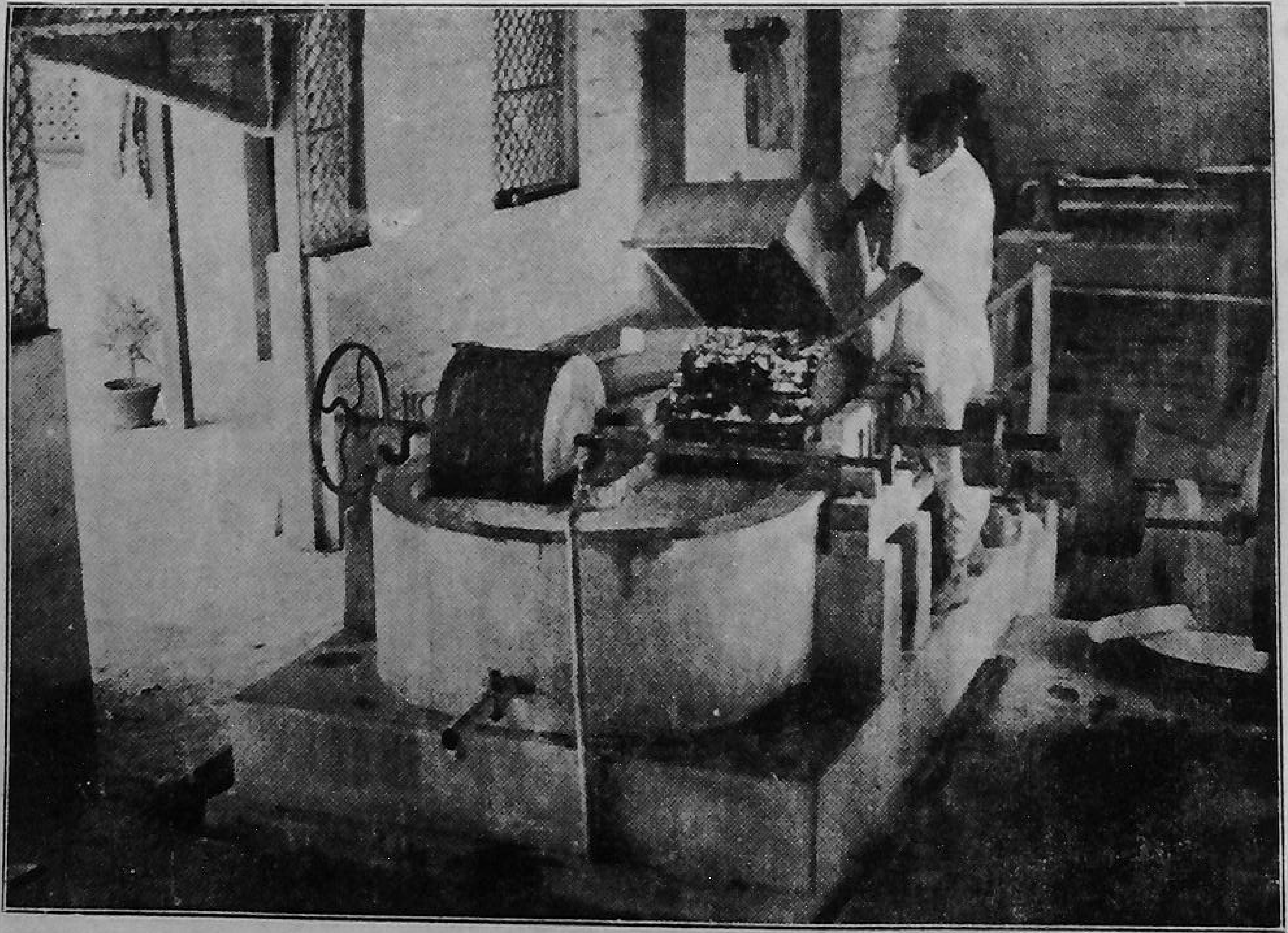
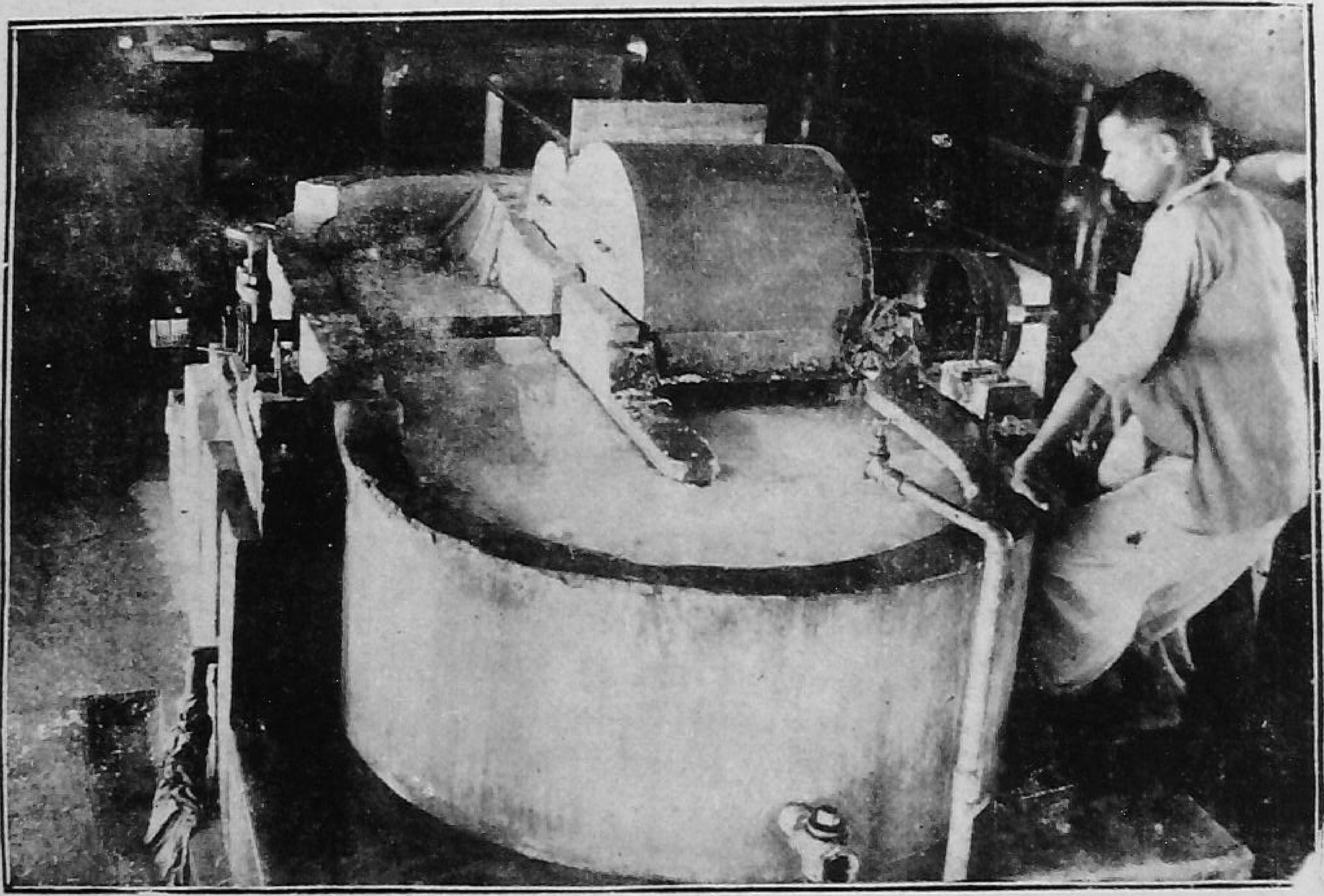


Plate 4—Beater with the drum washer on & hood partially removed



Beater in action, washing drum removed

The bed-plate is fixed into the compartment directly under the roll and the door is closed tight to prevent leakage of water (see plate 3). For the different varieties of paper the edges of the blades of the roll and bed-plate are of different thickness. For absorbent papers the edges are sharp *i-e.*, 1/8" and moreover the angle of the bed-plate knives is more than 5 degrees. For documentary, bond, drawings etc. they are blunt *i.e.*, 3/16" to ¼" thick.

4. Hood. The hood is simple in construction and can be followed by a careful observation of the *drawing* and *plates.* The sides are made of semi-circular boards 1" thick covered with galvanized iron sheet.

Generally a gap of about 2" is left between the cover and fly bars of the roll so that they are not obstructed in their movements. The doctor prevents the back draw of the stuff and allows it to flow forward over the back fall. The hood prevents splashing of the pulps.

5. The Drum Washer. Its requirements are:—(1) One iron bar 7 feet long and 1¼" square turned at both ends. (2) One wooden block K 15" long and 3½" square having a central hole of 1¼" square to allow the shafting to pass through. (3) Two wooden discs 22" in diameter and 1" thick. (4) Galvanized iron sheets of 24 gauge. (5) Two pieces of wire cloth 6' long and 15" broad and of 8 and 40 mesh respectively. Construction: the inner side of each of the wooden disc is covered with G.I. sheet by means of nails. They are then fitted into the wooden block K. Four galvanised iron scoops (water lifters) are now made between the discs extending from the wooden block K to the circumference with a peculiar semi-circular curvature (see section across drum washer). These scoops are riveted into the discs and the block K. The drum thus formed is covered with the strong wire cloth of 8 mesh per inch over which the other sheet of wire cloth of 40 to 50 mesh is laid. Four holes are made in one of the discs at places where it meets with the block. These serve as exit for the dirty water raised by the inside scoops.

The square bar is now fitted into this drum at the proper position. A grooved pulley 24" in diameter is attached to this

at one end and the drive is taken by cross rope or cross belt from the roll-shaft. When the washer is in operation the buckets lift the dirty water and throw it on the wooden axle K from which it drains away through the holes in one of the discs. Wire screen allows only the water to pass through but not the pulp. The screen should be fine as otherwise, pulp will pass through it.

The drum washer should rotate slowly *i.e.*, 15-20 12. r.p.m. as otherwise, the dirty water thrown on the axle will have no sufficient time to drain away. The direction of rotaion of the drum and consequently the curvature given to the scoops should be opposite to the direction of rotation of the beater roll, so as not to obstruct the flow of the pulp in the beater.

The detailed explanation and a careful study of the *drawings and plates* will give a complete idea about the construction of a beater and its different mechanisms. The beater illustrated is intended to be worked either by 4 to 6 bullocks or by a small power and makes about 30 lbs. of rag or 50 lbs. of other pulps per day of eight hours. The average power required, comes to $2\frac{1}{2}$ to 3 horse-power. A beater of smaller dimensions may be constructed for hand drive. See plate 5 for hand beater.

The hollander beater is a very useful appliance. It can be used to perform four or five operations, *viz.* washing, bleaching, beating, dyeing and sizing with rosin. It not only saves space but every operation is also performed more satisfactorily.

Beater operation. Before starting the beater, the roll is raised up from the bed-plate; so as to leave a clearance of about $\frac{3}{4}$" space between them. The lowering and raising of the beater must be equal from both the sides. This can be done by testing the axle with a level bottle every time a change is made. If this care is not taken then the blades of the role and bed-plate will wear unevenly on one side or the other which is not desirable for the production of good pulps. The trough is half filled with water and the roll is set in motion. Then the material is added in small portions at a time and stirred all the while in order to prevent lump formation which causes

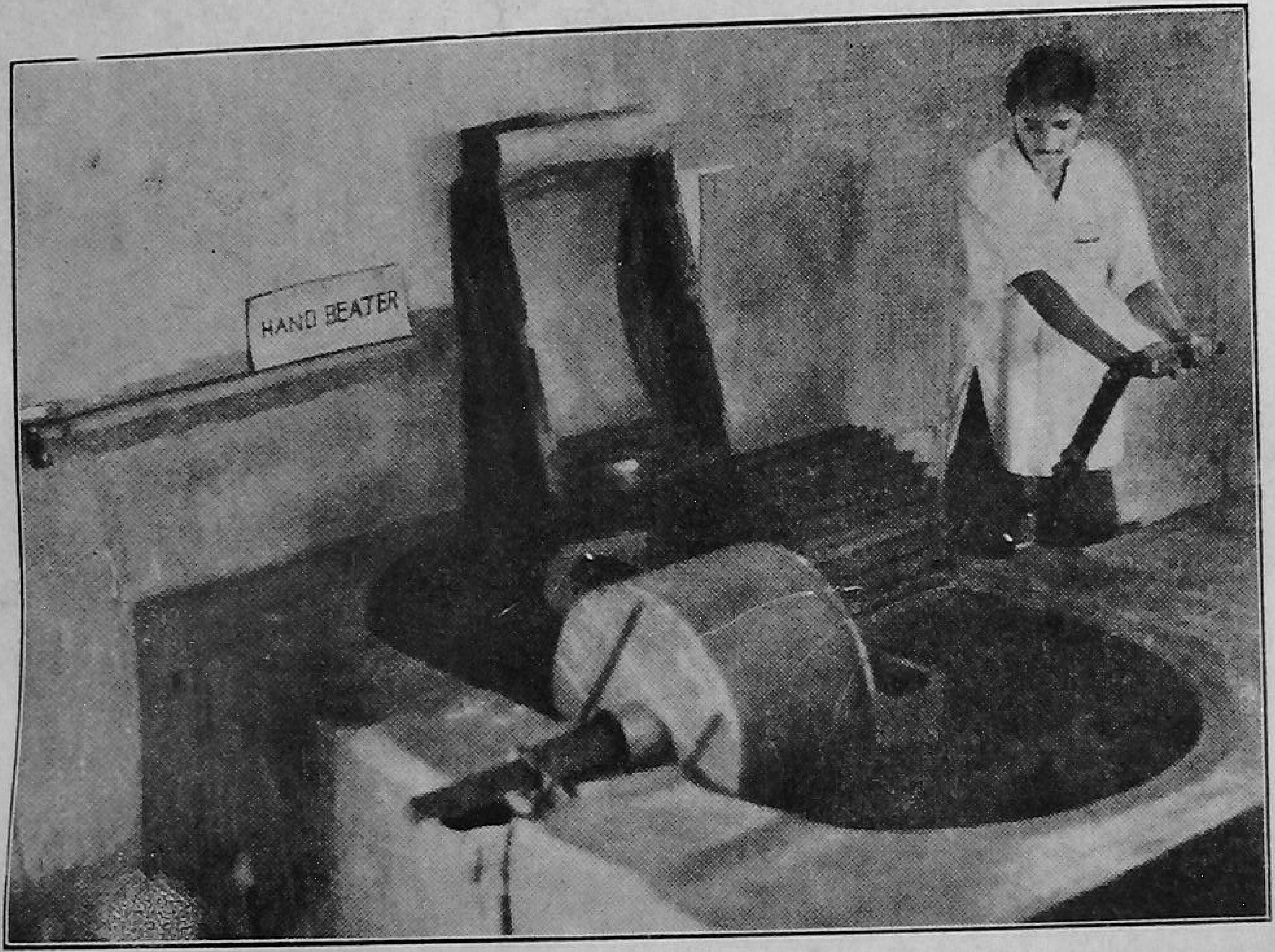


Plate 5.—Hand beater, with roll and washer

trouble under the roll. When all the material is into the trough more fresh water is poured in, so as to keep its level 2" or 3" from the top. The material together with the water is set in motion by the revolving blades of the roll and passing between the roll and the bed-plate gets loosened. It is now thrown over the back-fall and travelling round the trough again comes under the roll, causing the fibres to separte more and more every time. The heavy particles such as sand etc. are entrapped by the sand-trap. The lodgement of the pulps at the side of the roll is prevented by two small strips of wood or iron called bangers (see Fig.4) which throw away the pulps over the back-fall from the sides.

For washing, the drum washer is set in motion by a cross rope from the shaft of the roll. The drum washer must be partly immersed in the pulp so that the dirty water is caught by the buckets. The wire-gauze covering prevents the pulp from finding its way into the washer. During its rotation the dirty water caught by the inside scoops or buckets is thrown on the wooden block from which it finds it way out through the holes in one of the side discs.

Fresh water is poured from a tap or buckets so as to maintain the pulp at a constant level. When the washing is complete the washer is removed. Washing by this method is more thorough as the dirt gets loosened along with the fibres by the action of the roll. In case of bleaching the requisite amount of the bleaching solution is poured in, after thorough washing. The roll may be put out of action periodically during the bleaching operation. This way of bleaching is more efficient owing to the good stirring action of the roll. If the beater is required for beating other pulps, then after adding the bleaching solution it may be run for about ½ hour and the contents emptied into another receptacle where the pulp may be stirred occasionally till it is bleached. In the meanwhile the beater may be used for beating the other stuff. After bleaching, the pulp is washed as before. Then the beater roll is gradually lowered down by turning the capstan headed screw. Each time the fibres are more reduced. Ultimately the roll is put down hard over the bed-plate for the final reduction of the fibres into pulp.

Beating of pulps. The beating of the pulps is governed by the following conditions.—

(1) The kind of paper to be made.

(2) Characteristics of the ultimate fibres in the half stuff from a particular raw material.

The production of the pulps suitable for different kinds of papers is manipulated by (*i*) having the beating faces of the bars of the roll thick or thin *i.e.* blunt or sharp. (*ii*) furnishing the beater at high or low concentration *i.e.* keeping the consistency of the stuff in water thick or thin. (*iii*) Lowering the beater slowly or quickly, or the duration of the operation of beating.

It will be apparent from the above that by varying the different conditions, suitable pulps can be produced for the production of different varieties of paper.

Free pulps. If a blotting paper is required the pulps are not required to be bruised and hydrated as thereby the fibres lose the characteristics of absorbency. Blotting paper is not required to be strong. It must have greater absorbing power which is a capillary phenomenon of the fibre. This is lost by slow beating. Hence the pulps are beaten quickly. This is technically known as "free beating." In order to obtain this condition the knives of the beater roll and the bed-plate should be sharp *i.e.* about 1/8th of an inch at the cutting surface. The bed-plate blades may be fixed at a greater angle to the axis of the beater. This will have a more scissoring or cutting action on the fibres than when the knives are blunt and the angle between the bed-plate and roll is less. The consistency of the half stuff in the beater must also be less as thereby the pulps will offer less frictional resistance to the action of the cutting blades of the beater roll than when it is charged at a greater consistency. Generally a consistency or the concentration of the half stuff in the beater is kept at not more than two per cent of the dry stuff. The beater roll is lowered on the bed-plate as quickly as possible to avoid any chance of the fibres being bruised. The beating time generally allowed for such pulps is from 1 to 2 hours. In short the fibres for blotting or absorbent papers should receive the

maximum number of cuts so that they will not change their original characteristics of sucking liquids, except in reducing their fibre lengths. In order to produce pulps for blotting, filter or other absorbent papers, the following conditions should be observed.—

(1) The knives of the beater roll and bed-plate should be sharp. *i.e.* 1/8" at the beating face.

(2) The blades of the bed-plate should make a greater angle to the axis or to the blades of the beater roll; or they may be elbow-shaped.

(3) The concentration of the stuff in the beater should not be more than 2%.

(4) The roll should quickly be lowered hard on the bed-plate.

All this will have an effect of producing "free pulp." The fibres have no chance of getting hydrated. The water drains away quickly from the paper-lifting mould in forming the sheets. Such pulps cannot be satisfactorily produced by the dhenki.

Wet pulps. These pulps are used for the production of strong papers, such as bonds, documentary, drawing paper etc. Since the paper is required to be strong the fibres are not cut as in the previous case, but they are sub-divided by bruising, tearing etc. The beater is charged at a greater consistency of the stuff *i.e.* more quantity of the half stuff, usually at 5 to 6% concentration. The knives of the beater roll and the bed-plate are blunt *i.e.* about ¼" thick. Usually the angle of the bed-plate bars with those of the roll is not greater than 4° to 5°. The beater roll is lowered slowly on the bed-plate. Usually it takes about 8 to 10 hours to beat pulps in the case of the strong cotton rags for the production of bond or documentary paper. With the beater high up from the bed-plate, the first action of the blunt knives of the beater roll is the rubbing of the fibres between the bars of the bed-plate and the roll, so also against the walls of the midfeather and the trough. During the violent action of the roll, the mass is drawn suddenly in front of the beater roll. The first effect of all these actions is the separation of

the individual fibres from the clumps or in the case of rags, the threads are loosened from the woven fabric. Next the threads are untwisted and separated into individual fibres, or in other words it undoes the work of a weaver and a spinner. When the separation of the fibres has advanced considerably, the roll is lowered a little more towards the bed-plate. As the pulps become thinner the beater is lowered more and more from time to time.

During all this period the blunt knives of the beater roll exert a bruising and rubbing action on the fibres. This effect is maximum when the concentration of the stuff in the beater is high, as in that case the quantity of the fibres coming between the bed-plate and the roll being greater they will offer a frictional resistance to the blows of the beater roll or in other words they will have a cushioning effect to the knives of the roll with the result that there will be very little cutting action on the fibres. However they will be sub-divided by the crushing or hammering action of the blunt knives of the beater roll. As the fibres get more and more bruised they are also softened. This softening is also due to the friction or rubbing caused between the fibres themselves and between the fibres and the blades. During this bruising and softening action the fibres absorb water and swell and assume a greasy appearance. They get a gelatinous coating over the surface. Such pulps do not part with the absorbed water readily from the pulps on the paper-lifting moulds. Hence they are called "wet or slow pulps." In the end when the fibres are required to be reduced to smaller units the roll is put down hard on the bed-plate without coming in the way of its free movement.

For thin papers the fibres are not more subdivided or reduced in length but they are well bruised by prolonged beating and the beater is not put down hard over the bed-plate. For thick papers, the beating is not so much prolonged *i.e.* the pulps must not be too wet as thereby it will be very difficult for the water to pass through the thick layer of the wet pulp on the paper-lifting mould. After a certain amount of bruising has taken place the beater is brought in contact with the bed-plate. Generally 6 or 7

hours beating for rags will be sufficient. In order to get the pulps reduced in a shorter period, the concentration of pulp in the beater should be somewhat lesser for thick paper.

For ordinary writing paper the duration of the beating operation is limited from 3 to 5 hours depending on the initial characteristics of the fibres in the half stuffs from different raw materials.

Since, during the wet beating of the pulps, the fibres get swollen with the water of hydration the paper shrinks while drying, in proportion to the hydration of the pulps in the beater.

This shrinkage together with the increased felting of the bruised fibres during wet beating increases the strength of the paper. The paper from wet beaten pulps appears more transparent, rattles well and is strong and owing to the gelatinous condition of the beaten fibres, it is less absorbent. Hence it requires less sizing materials to make it non-absorbent.

The second factor that is required to be considered is the character of the fibres *viz.* the length and strength of the fibres. The cotton fibres being longer and stronger can withstand more pressure before they are reduced to pulp, but in the case of fibres from straw, plantain etc., they are already shorter and weaker than cotton and require only light treatment, the beating operation being limited only to the separation of the individual fibres. For this, the beater is not lowered hard upon the bed-plate. If the fibres are reduced beyond a certain limit, they will weaken the paper. The fibres from straw, plantain etc., are weak and contain more of beta-cellulose. Such fibres hydrate readily even with bruising and rubbing. If the beating of the cellulose from such materials is prolonged beyond what is necessary for the separation of the fibres from the lumps, the pulps get highly hydrated and in making sheets great troubles are experienced as the water does not drain away within a reasonable time.

Papers produced from highly hydrated pulps have a tendency to cockle in the dry weather with lower humidity. Artificial parchment paper can be produced from highly

hydrated pulps. Plantain fibres hydrate very readily in a short time (generally 3 to 4 hours). Paper made from this pulp looks like an imitation parchment paper.

At the end of any beating operation the beater roll is raised up while in motion and continued to work for 15–20 minutes whereby the pulps are churned. This helps in separating the fibres from the lumps, to a certain extent.

If the pulp is to be sized with rosin the necessary amount of the rosin soap solution is added and allowed to mix well. If any starch or French chalk, etc., are to be mixed they are first made into a paste and poured either before or along with the rosin solution. After about fifteen minutes' well mixing, solution of alum is added finally. When the pulp is to be dyed, the solution of the colouring matter is added before the rosin soap solution but not afterwards. Except beating, all the other operations are not necessarily performed in the beater. The choice remains according to the convenience of the operator.

To test whether the pulp is proper or not. From the finally prepared pulp, take some of the size of a betel-nut and with the tips of the fingers stir it in a tumbler (preferably glass tumbler) filled with water, when the pulp should be free from lumps or unreduced fibres or knots. The separation of individual fibres must be clear, and the mixture of the pulp with water must be homogeneous with the general appearance of thin starch paste (kanji). In case it is found that the pulp contains knots or unreduced fibres, it should be given more beating or rubbing treatment, or be thinned with water and strained through a sieve of appropriate size. The sieve chosen should be of the slit type and not of the square type. The residue on the sieve may be beaten to pulp in the subsequent charge. If the pulp is not uniform then the knots finally appear in the paper with the possibility of tearing it in the process of glazing or making the paper unfit for smooth writing. Such sheet has a bad look through.

CHAPTER VII

TREATMENT OF THE DIFFERENT RAW MATERIALS

(1) Cotton Wastes and Cotton Rags

Cotton fibre. Cotton fibre is the purest form of cellulose that occurs in nature.' It contains nearly 90% cellulose, about 3% of the non-cellulose matters and 7% of natural moisture. The fibres are about $\frac{3}{4}$ to $1\frac{1}{4}$ inch long. Cotton cellulose contains almost 99% of the resistant alpha-cellulose. If the cotton fibres are seen through the microscope they look like a twisted hollow tube with thin outside wall. This peculiar twist or cork-screw appearance gives the characteristic bulky appearance to the paper as there remain hollow spaces between the fibres when they are brought close to each other. In order to get an idea, a comparison may be made with two rubber tubes placed side by side once in the original form and next in a twisted form as shown in figure 5.

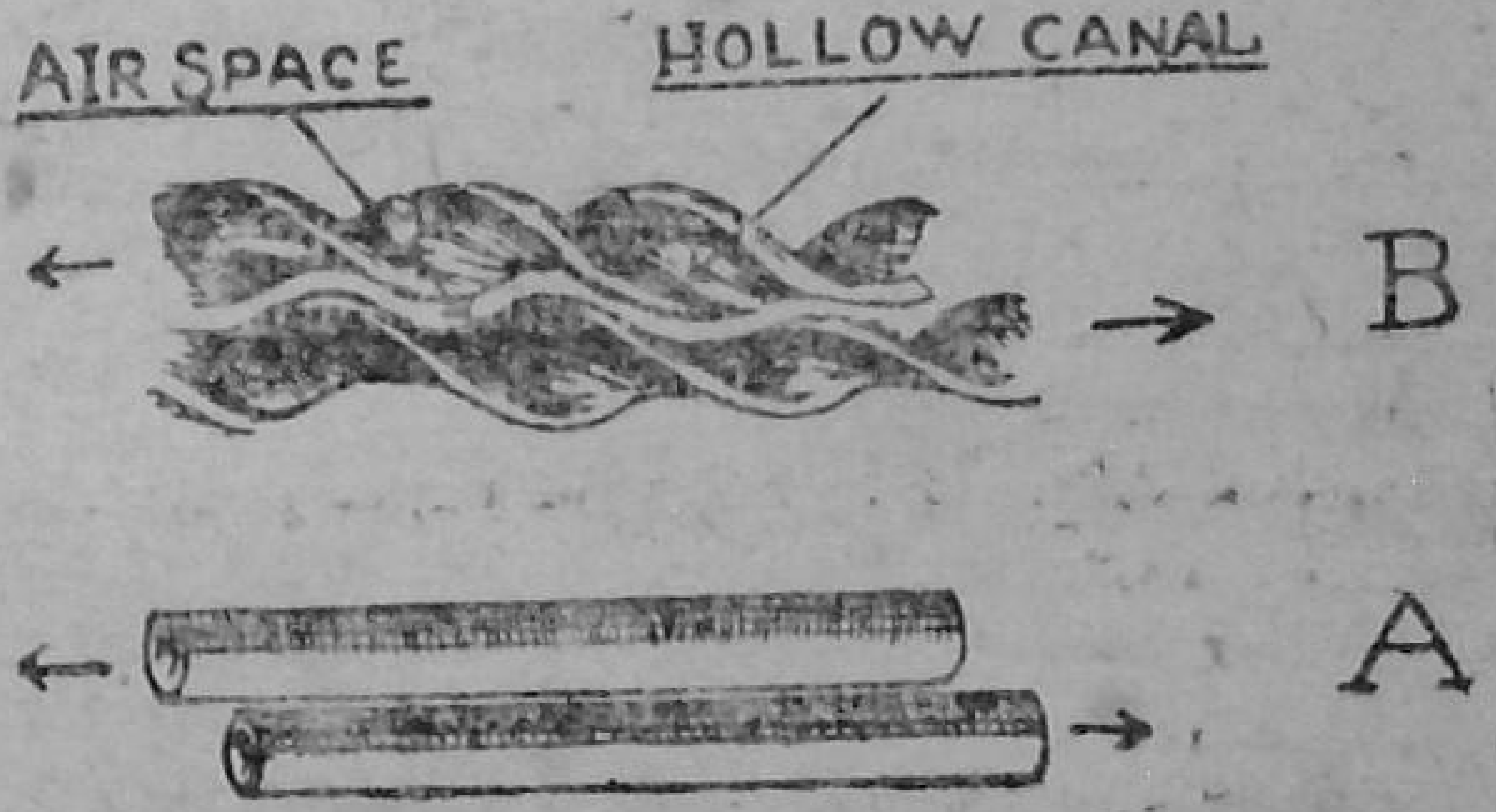


Fig. 5

When the two tubes are close together as at A, there are no air spaces between them. Such tubes being cylindrical and smooth can be pulled apart in the direction shown by the arrow. But if the tubes are twisted and placed close together as at B it will be found that they leave air spaces and also cannot be pulled apart so easily. The wide central hollow canal and thin walls of the fibres with the empty air spaces between them give the peculiar character to the cotton paper.

It is to be expected that the cotton paper will be more absorbent and bulky. The strength of cotton paper is partly due to this twisted form of its fibres which in juxta position cannot be pulled apart so easily.

Cotton fibres being thin walled are not much split longitudinally as in the case of thick walled fibres but they are fractured while beating. In order to understand it clearly we may compare the cotton fibre to a twisted paper tube and the thick walled fibre such as linseed or sunn-hemp to a piece of bamboo. If the paper tube is hammered it will show no longitudinal splitting exactly like bamboo but a fracture with rough ends or the fibres may be split or bruised having the appearance of a paper tube whose ends are scissored longitudinally. But in the case of bamboo whose wall is thick, the blow of the hammer will split it longitudinally along the axis, into numerous splinters. Hemp and linseed fibres are split like bamboo as explained above.

Cotton fibres take a long time to hydrate. The fibres being thin walled and consequently soft do not require hard pressure with a heavy roll for reducing them to pulp as in the case of hard fibres such as linen. Cotton cellulose being pure and more resistant coupled with the peculiar physical characteristics of the fibres, is admirably adopted for the production of different varieties of paper such as blotting, filter, writing, documentary etc.

The composition of raw cotton-fibre is as under:—

Ash ...	1·21%
Moisture ...	7·00%
Water solubles ...	4·90%
Alkali solubles ...	4·40%
Cellulose ...	82·60%
Other matters by difference ...	1·10%

The form in which cotton waste is available to the paper maker is raw cotton from third picking, fly waste from textile mills, cotton seed linters, waste of textile or garment manufactures such as yarn waste, rags-bleached and unbleached,

hosiery and tailor's trimmings and old wastes as used garments, ropes etc.

(*a*) Third picking Cotton and Fly waste from mills. The impurities that are likely to be present in this kind of wastes are bolls, trash, sand, cotton seeds, stems, etc. This kind of waste would not be easy to clean by the ordinary process. The waste may be carded with a carding-bow and hammer. This would remove harder portions such as trash bolls, leaf-stalks etc.

The cotton waste should be boiled in the open pan or digested at about 25 lbs. pressure with 4% of caustic soda on the weight of the raw material. The bleaching powder required will be 5% of the original material. The expected yield of the pulp will be about 75 to 80%. Cotton waste would require a comparatively shorter period (about 4 or 5 hours) for reducing it into pulp than that for rags as the fibres are loose, not being woven or spun. This should be utilized for making writing paper, filter paper etc. Cotton will not yield as strong a paper as from cotton rags.

The difference between the digested and open boiled cotton will be that the former will yield purer cellulose than the latter. The consumption of bleaching powder will be somewhat more in the open boiled cottons.

(*b*) Cotton Seed Linters. This form of waste is obtained from cotton seeds by delinting them before they are milled for oil crushing. Impurities occuring in this cotton waste are whole or broken seeds, hull bran etc. This waste is also difficult to clean. The best plan is to wash the waste to remove the fine dust, hull particles etc., before they are treated with alkalis. The waste is preferably digested at 30 lbs. pressure for 4 hours with 12% of caustic soda. The consumption of bleaching powder is from 10 to 15% on the original raw material. The yield of the pulp is between 50 to 70% on the raw material. Since the fibres are immature and short, it is not expected to make a strong paper out of it. It should preferably be used for blotting or low grade writing paper. The beating is required only to separate the fibres. The surface of the paper is fuzzy.

(c) Cotton rags. The rags are generally obtainable as mill rags, bleached, unbleached and coloured; tailor's trimmings; hosiery trimmings; etc., in the manufacture of cloth and garments. They may be termed new cottons, and make a strong paper. The second source is old worne-out rags which make weaker paper such as soft writings or filter and blottings, as the quality of the cellulose is deteriorated during wear and tear and also washing several times either with soap or washing soda and with bleaching powder at the washerman's hands.

New rags are an excellent material for paper-making especially where strength, durability and toughness are required. Bond, drawing and special kinds of stationery are made out of new rags. In such cases the stock requires a longer time to be beaten into pulp. The fibres are kept somewhat longer and beaten with the blunt knives of the beater roll. The pulp can also be made conveniently under the dhenki in small quantities. The softer stock is made into blotting paper and filter paper, after retting.

The new cottons are generally pure cellulosic fibres together with the sizing materials added in more or less proportions to the yarn or fabrics during the process of weaving or finishing the goods.

Such materials are generally comprised of starches, china clay, French chalk, stearines, mineral wax, tallows or vegetable oils as sizing or finishing materials. They are required to be removed before they are treated with alkalis.

Starch has got a property of gelatinizing when boiled with alkalis. Hence if rags containing starch are boiled directly with the alkalis, the starch gelatinizes on the yarn. This impedes chemical action of the alkalis on the rags preventing thorough penetration. The starch so gelatinized is very difficult to wash away from the yarn. In such cases it is advisable to remove it before boiling with alkaline solutions. This is done by boiling the rags in plain water after the usual processes of sorting, cutting, etc., and keeping them for fermentation for about a fortnight. During this period the micro-organisms attack the boiled starch and solubilize it, in

which condition it is easily removed. In order to hasten this action some fungi from rotten bread may be incorporated into the boiled rags. They are afterwards washed and boiled with the necessary amount of caustic soda. The rags may preferably be boiled in open boilers (See fig, 1).

The beating of the cotton rags into pulp is a progressive operation. The first action is to loosen the yarn from the woven fabrics. Then the next action is to separate the yarn into individual fibres and the last action is to sub-divide them into small divisions (fibrillation). Naturally it is to be expected that it will take a longer time to beat the rags into pulps, than the cotton wastes. The harder the stock such as coarse cottons like canvas or hard spun yarn, the longer will be the duration of beating. Such stocks are specially adopted for strong bonds, drawing paper etc. But they would not yield an excellent blotting or filter paper.

Sometimes the fabrics are made of unions of silks and wool. Such unions are weeded out in the process of sorting. In case of doubt a small portion of the suspected piece may be burnt and if it gives the smell of burnt hair then the fabric contains either wool or silk in which case it should be rejected. Rags from artificial silk are also rejected for paper-making.

The rags may be divided into 6 classes according to their sources. They are :—

I Gray rags from mills
II Bleached rags from mills
III Hosiery rags from knitting works
IV Tailors' rags
V Coloured rags
VI Old worn-out clothes and tattered rags.

1. GRAY RAGS. Gray rags are cleaned and sorted and cut as usual. Since they are more or less heavily sized they should be treated to remove starches, etc., as described before. Caustic soda used for boiling will be between 5 to 7 per cent of the weight of the original raw material taken. Afterwards it is washed and bleached with about 5 to 6 per cent bleaching powder according to requirements. Before washing, the pulp

may be soured with a small quantity of hydrochloric or sulphuric acid, the former being preferable.

The bleached stuff is beaten according to requirements.

The pulps obtained from such rags vary between 50 to 70 per cent of the original raw material, as whether heavily or lightly sized.

II. Bleached rags. Generally these rags are lightly sized. In case the rags are heavily sized, containing more starch, they should be treated as for gray rags. The caustic required for boiling the rags is about 3 to 5 per cent and bleaching powder 5 per cent. The pulps obtainable are about 70 to 80 per cent.

If the rags are clean and lightly sized they need not be given the chemical treatments of alkaline digestion and bleaching, but be directly beaten to pulp. The rags after partially beating may be washed with 2 to 3 per cent soap previously dissolved in water. After thorough washing the beating process is continued till the pulp is made.

III. Hosiery waste. Hosiery yarn is not generally sized but lightly treated with a weak solution of turkey red oil or similar softening agent. After the usual preliminary processes the rags may be boiled with 3 to 4 per cent caustic soda or soda ash and bleached with 3 to 5 per cent bleaching powder.

In case the rags are bleached they may be directly beaten to pulp as described under bleached rags. The pulps obtainable from hosiery waste come to about 75 to 80 per cent of the original raw material.

IV. Tailors' rags. Tailors' rags are usually a mixture of all trimmings of the tailors' cut. They contain bleached and unbleached, white and coloured cottons together with woollen, silk and artificial silk trimmings. Besides these they contain a lot of foreign materials such as floor sweepings, etc. The rags are sorted into white and coloured cottons and the rest. The rags should be further cut into small pieces; seams of sewn pieces should be cut and loosened. Any buttons etc., should be removed. White rags should be treated as under 2 *i. e.* bleached rags. The coloured rags should be treated as

described under that head below. Woollen rags are sometimes lightly beaten to separate the woollen hair and incorporated into other pulps—not necessarily of rags—to give a mottling effect to the paper.

V. Coloured cotton rags. These are trimmings of coloured cloth either as mill rags or tailors' sorted trimmings, obtained from cloth which has been dyed with various colours mostly of coal-tar origin. Some of the colours are very fast to mild alkaline and bleaching treatments. Hence for a small manufacturer it will be difficult to produce white pulps from such rags. In mill practice the rags are digested with 10 to 15% of lime at a pressure of about 40 to 50 lbs. After bleaching, the pulps are somewhat whitish or of gray colour. The mixed coloured rags may be sorted into their respective colours and directly beaten into pulp with an intermediate soap treatment to produce coloured paper or after the usual preliminary treatments, they are boiled with 7 to 8% caustic soda, washed and bleached with about 10 per cent bleaching powder. The colour of the resulting pulp will be light gray.

The pulps obtained are usually about 70 per cent. The paper made from these rags is somewhat softer than that from the white stock. If the rags from chemical treatment are fermented they make excellent gray filter paper.

VI. Old cotton rags. There are two classes of old rags.

(1) Old clothes rejected by the middle class and rich people. The rage are cleaned sorted and cut as in tailors' cuttings. The white rags may be boiled with 3 to 4 per cent soda ash bleached with 3 to 5 per cent bleaching powder. The paper made out of this stock will be somewhat weaker than that from the new rags. These rags may be usefully utilized in making filter paper for which a softer stock is required.

The coloured rags may be treated as for new coloured rags. The paper made out of this stock may vary in colour but will be weaker and softer. Blotting and filter paper may be made out of it.

(2) The old clothes rejected by the very poor people. This stock is quite dirty and too weak and makes a very

soft and weak paper hence this is an ideal stock for blottings. The rags are sorted to remove only the woollens, silks and artificial silks but not necessarily the coloured rags. The rags are out, dusted, cleaned and washed as usual and boiled with 5 to 8 per cent caustic soda. The pulp need not be bleached but coloured with pink colour and used only for blotting paper.

Note ;—Old rags either white or coloured are generally collected from streets or dust-bins and they are likely to carry infectious diseases, so it is better to spread them in the sun for some days no sooner they arrive at the factory before they are taken for processing. Even in the case of household old rags it is advantageous to take the same precaution.

(2) SUNN-HEMP

The old paper-makers in India used mostly sunn-hemp waste in the form of old gunny bags. This should not be confused with the common gunny bags made out of jute. Sunn-hemp is grown for its fibre in many parts of India. The fibre is extracted from the retted stalks after the crop is collected. It is lustrous in appearance. There are two varieties known as Devgad and Jubbulpore hemp. The former variety is considered to be the best. It is used in the manufacture of textiles such as ropes, twins, gunny bags, fishing nets etc. Finer varieties are used to a small extent in cloth manufacture. The form in which it is used for paper-making is the toe or short fibrous waste in the combing process of cleaning the fibre, old fishing nets, gunny bags, ropes etc. Generally it is not used in the raw state for paper-making owing to high cost of the fibre. It yields from 65.0 to 80.0% cellulose according to its climatic conditions of growth, nature of the soil and freedom from impurities such as stalks, cuticular portion etc. The sunn-hemp cellulose consists predominantly of the more resistant alpha cellulose, being about 93–97.0%. Hence paper made by the old village paper-makers, was durable. Such paper is in a fair state of preservation in the form of sanads, court documents, account books, MSS etc.

The cellulose fibres are fairly thick walled with a narrow central hollow canal.

The raw fibre of the old wastes consume about 80 to 90% of alkali. The raw material is preferably digested at 60 lbs. pressure for four hours using 12 to 15% of caustic soda. The unused alkali from the digested liquors can be used for soaking the fresh charge before digestion. This would require less alkali in subsequent digestion. The consumption of bleaching powder comes to about 50%. The half stuff yields itself well to the bruising action of the dhenki and beater roll. By manipulating the beater, suitable pulps may be produced to prepare different varieties of paper. With 5% concentration and 3 hours beating period long fibred pulps suitable for thinnest copying paper are produced, which can take the impressions of the types from the typewriter.

With about 6 to 7% concentration and eight hours beating, well hydrated and bruised pulps, suitable for strong papers such as bond, drawing, etc., are produced.

In India, for hand-made paper, this is an excellent raw material.

The composition of raw sunn-hemp fibre is :—

Water	...	7.7%
Water solubles	...	11.5%
Mucilaginous matter	...	9.7%
Lignin (by difference)	...	4.7%
Cellulose	...	66.4%

(3) LINSEED FIBRE

Linseed is an important crop in India. In cold countries the crop is grown for its fibre known as flax. The finer varieties are used in making linen cloth. Linen and flax are considered one of the best materials for paper-making. In India the plant yields oil seeds. The stalks are mostly burnt away. However, they give about 8-10% coarse fibre which is useful for paper.

The fibre is extracted in a crude manner, hence it contains shivers or stalk pieces which are very difficult to remove. If a clean fibre free from shivers is obtainable, then it forms an excellent material for high class paper similar to

cotton rags. The crude fibre is brittle and lignified. Partially cleaned linseed fibre is digested in 2% caustic soda solution at a pressure of 60 lbs. per sq. inch. The actual consumption of caustic soda is 9%. The unconsumed alkali from this digested liquors is used for soaking the subsequent lots of the fibre as in the case of sunn-hemp.

The bleaching powder consumed is 5 to 6 per cent.

This gives a creamy white or white pulp. The cellulose yields itself well to the action of the beater roll. It may be beaten like sunn-hemp to produce different grades of paper.

Linseed contains about 95% of the alpha cellulose. Hence the paper will be stronger and durable like sunn-hemp.

The composition of the crude fibre is :—

Water	...	8.2%
Water solubles	...	16.5%
Mucilaginous matter	...	14.7%
Lignin matters by difference	...	11.0%
Cellulose	...	49.6%

(4) JUTE WASTES

The form in which such wastes are available for paper-making are old worn-out gunny bags, old cement bags, rags of hessian cloth, waste string cuttings etc. In the case of old gunny bags, stitches are cut and the cloth is thrashed to remove adventitious dirt like mud, broken grains or cement etc. They are then cut into small piece of about an inch or two in length. The cut tags are again thrashed lightly on a sieve to loosen the fibres and to separate the dust which may have found its way inside the threads and pores in the cloth. Afterwards it is usually washed so that it will be free from the adhering dirt. Then it may be retted as per instructions (infra) or may be boiled with 12–15% caustic soda for 6 hours and washed and bleached with 10% bleaching powder. Jute is a ligno-cellulose which will not be freed completely from the lignin material by the boiling process. Hence it would consume a lot of bleaching powder before it is made into white pulp. This deteriorates the quality of cellulose. Hence only partially bleached pulps should be produced. Such pulps have a creamy yellow colour.

Since the cellulose fibres of jute are short and weak it is not used for making strong and durable paper, but is only used for writing and other similar purposes. The time taken for beating jute into pulp is about 4 hours. By digesting jute waste with 8 to 10% lime at about 30 lbs. pressure, the resulting pulp can be used for wrapping or packing paper. Such pulps are not bleached. The unbleached or partially bleached pulp yields a stronger paper than fully bleached one.

Composition of jute thread waste :—

Moisture	...	8.2%
Water solubles	...	7.3%
Mucilaginous matter	...	9.1%
Lignin (by difference)	...	16.4%
Cellulose	...	58.4%

(5) RICE STRAW

Rice straw is an easily convertible raw material. The harder stem tops with the unripe grain or husks are cut and rejected as they do not easily lend themselves to the chemical treatment and hence they appear as hard specks in the paper. The rest of the straw is chopped to about an inch pieces either by hand or in a grass chopper. The chopped straw is once thrashed on a sieve to remove any grain or small stem pieces and washed. It is then boiled with 15% alkali for six hours and washed and bleached with 8 to 10% of normal bleaching powder. This gives a snow or creamy white half stuff. The fibres of the rice straw cellulose being small are not required to be reduced to small dimensions under the action of the beater roll. The beating operation is limited to the separation of the individual fibres by brushing and rubbing. For this the beater roll should not be put hard over the bed-plate. The straw cellulose hydrates readily and produces a somewhat translucent paper in proportion to the hydration. The cellulose contains about 73.0% alpha cellulose. Hence it is not suitable for high grade paper, but it is useful for writing paper, and low-grade blotting paper Rice-straw can also be converted into pulp by simply trampling and rubbing the treated material in the same way as waste paper without dhenki or beater.

Rice and wheat straw treated partially with 5.0% caustic soda or 10.0% lime for 3 to 4 hours in an open boiling tank and subsequently washed and reduced to pulp yields excellent straw-boards.

The composition of the rice straw is—

Water	...	8.4%
Water solubles	...	11.0%
Pectins and lignins	...	45.8%
Cellulose	...	34.8%

Wheat straw :—

Water	...	9.4%
Water solubles	...	10.9%
Mucilaginous matter	...	47.2%
Cellulose	...	32.5%

Note :—These results differ widely from the standard results for the European straws. The cellulose percentages are lower than those in foreign straws which yield about 46% of cellulose (See "Paper-making" by Cross and Bevan).

(6) BAMBOO

Bamboo is found in abandance in the Indian jungles. Of late it is coming into prominence as a paper-making raw material. Much work has been done on it at the Forest Research Institute, Dehra Dun. Very useful information can be found out from the publication on "Digestion of grasses and bamboo" by W. Raitt. On a small-scale it may not be possible to follow the details in the book. But it is possible to produce slightly greyish white paper by digesting the bamboos twice with caustic soda instead of following the sulphate (properly speaking sulphide) process. The form in which it is used is the old baskets and mat-makers' shavings, old mats or new bamboos. The new bamboos should be crushed to small splinters by hammering. The inter-nodes being pithy and friable would be reduced to small fragments which should be rejected as they are not easy to digest and appear as cellular speaks in the finished sheet.

The bamboo splinters, old baskets and mats are next cut or broken into small pieces of about 3 to 4 inches in size.

They are then once washed with water and boiled with 5% caustic soda in the open boiler for four hours. The boiled material is washed and any hard portions are crushed. The material is next digested in small quantities with 15.0% caustic soda at a pressure of 50 lbs. per sq. inch for 4 hours. The digested material is washed and lightly beaten just to loosen the lumps and bleached with 12.0% bleaching powder. This would give greyish white pulp. The pulp obtaining by this method is about 40.0 to 42.0%.

In case writing paper is not to be made then the bleaching process is omitted. Such pulps are useful for wrapping and brown paper. They may be coloured with brown colour.

The ultimate fibres of the bamboo cellulose are small and hence the pulps are not beaten hard and are made in 3 to 4 hours time.

Bamboo contains about 46.0% cellulose.

(7) PLANTAIN STEM FIBRE

After the fruit is taken out, plantain stems are thrown away or are used as a manure although as such they have very little value. The petioles of the stem contain too much of pithy matter which is troublesome in producing good quality paper. They should be crushed in sugarcane rollers or preferably be treated in some fibre-extracting device and washed to remove as much of the pithy matter as possible thereby getting cleaner fibre which should be used for paper-making. Each stem gives about 2 lbs. of the fibre. The yield of fibre depends on the variety and growth of the plantain stems.

The cleaned fibre requires 12 per cent of caustic soda for boiling and 20 to 25 per cent bleaching powder to make the pulp white. One characteristic of the fibre is that it hydrates very readily, hence excessive beating should be avoided. If a beater is used then the action of the roll should be just to brush out the fibres. The pulp should be made within the least possible time. If beaten excessively the paper is liable to cockle. The plantain paper appears somewhat like imitation parchment paper. The pulp obtainble from the fibre is about 30 to 33 per cent. The fibre may preferably be used for

making craft paper In which case about 5 to 6 per cent of caustic sona may be used without any bleach.

(8) SUGARCANE TOPS AND TRASH

Sugarcane tops and trash are the waste materials from the sugarcane farms. While crushing the cane for the production of jaggery (gul) or sugar, the tops are rejected as they have very little sugar contents. They are either burnt away or used as compost on the sugarcane farm. The stem portion is sometimes fed to animals working on the farm. The yield of such cane tops with leaves is about 20.0% of the sugarcane crushed or about 6 to 8 tons per acre. These form an excellent raw material for making straw boards for which the whole tops or the leaves may be used. They may also be used for making wrapping paper.

By boiling or digesting the whole tops and leaves with 8.0% alkali for 5 hours, suitable pulps would be obtained for the production of superior boards such as mount or box boards. The yield of the boards is about 40 to 45%.

The trash is the leafy portion of the sugarcane. By treating it with 4 to 5% caustic soda or 20% lime, either in the open boiler or in the digester at 40 lbs. pressure, suitable pulps would be obtained for the production of ordinary packing or straw boards. The yield of such pulps is about 50.0%.

The pulps for the boards may be made either in a hollander beater or in a chunam mill driven by bullocks or under the dhenki. About 3 units of electric power are required for converting 50 lbs. of the original raw material into pulps. For the production 8 lbs. of pulps, the electric energy consumed will be one unit.

In order to give weight and smooth surface to the finished product, the pulps may be loaded with 20–25.0% of China clay or yellow ochre and sized with 2.0% rosin and 3.0% alum on the weight of the dry pulps. The yield of the loaded boards will be about 48–50% in the case of the whole tops or 55 to 60% when only the trash is used.

The boards produced from the digested materials are darker in colour than those produced from the open boiling system. Caustic soda treatment is better than lime.

For the production of wrapping paper the tops or the trash may be treated with 8.0% caustic soda either in the open boiler or digester. The pulps should be made by the slow process of beating. The fibres should be fairly long.

The wrappers from the sugarcane tops are better and stronger than those from the trash only.

All the above results are based on air dry materials.

The composition of the sugarcane tops and trash :—

		Top with trash air dry wt	Trash
Moisture	...	× ×	12.0%
Water solubles	...	22.0%	8.0%
Alkali Solubles	...	22.0%	36.0%
Cellulose	...	36.2%	28.0%
Other matters	...	19.2%	16.0%

(9) BUL-RUSH

Bul-rush is a weed growing in abundance in the canal areas and marshy places. It is a nuisance in those areas almost similar to water-hyacinth. It is variously known as pan-kanis, jungli bajri, panad, ramban etc. Its botanical name is Typha elephantina. It has so far no economic use. It was tried experimentally as a paper-making material but it was found to be uneconomic for such use as it yields only 25.0% of paper. It consumes large amounts of caustic soda and bleaching powder. The paper produced is weak.

However, it is a good material for wrapping paper and boards for which it is treated in the same manner as sugarcane trash. The yield of the pulp is slightly lesser than that from trash.

The composition of the bul-rush :—

Moisture	...	16.0%
Water solubles	...	6.0%
Alkali solubles	...	38.0%
Cellulose	...	29.0%
Lignins by diff.	...	11.0%

(10) PAPER WASTES

Paper-making from waste paper is simply a process of reconversion. The different processes of paper-making such as chemical treatments, beating and sizing etc. have already been performed on some raw materials, before the original paper was made out of them. The use of the alkalis and soaps in reducing the wastes to pulp is simply to remove the sizing materials on the paper. The process of rubbing and trampling is performed to separate the felted fibres from the desized paper.

Paper wastes are generally of 6 kinds :—

1. Book binder's and printer's waste paper or cuttings.
2. Writing paper and written wastes like letters, examination papers' etc.
3. Old books and old records.
4. Wrapping paper and similar waste.
5. Office correspondence.
6. Old newspapers.

1. *Book-binders' and printers' wastes.* They are generally obtained as cuttings of all sorts of paper, pulp, boards, binder's cloth, and all other materials used in book-binding. The waste contains papers made out of chemical or mechanical pulps out of which only the former is useful in paper-making for writing purposes. The latter is eliminated as it is not suitable. It may be used in making cover or envelope paper or for boards.

To distinguish between the mechanical and chemical pulps a dilute solution of aniline sulphate or caustic soda solution is used, which imparts yellow or brownish colour to the mechanical pulp while the chemical pulp is not coloured. The general physical tests are that the paper from the mechanical pulp is dull or grey in appearance and weak. By sufficient practice it will be possible to distinguish between the two merely by their appearance.

The pieces of boards, cloth, pins, etc., are rejected. The suitable waste having been selected, is once washed to remove the adhering dirt and mixed with 3 to 4% soda ash dissolved in water. After well mixing it is kept for 3 to 4 days. During this period the soda acts upon the sizing material in

the paper and softens the fibres. At the end of this period the pulp is trampled under feet in trampling pits or is pounded by a wooden mallet in a pit or wooden mortar or rice pounder. Then it is rubbed on a floor made of rough stone or cement concrete till all the bits or chits are reduced to pulp. The pulp is then thoroughly washed. It may afterwards be treated with 1 to 2% of soap and again rubbed and washed. The pulp may finally be bleached with one to two per cent bleaching powder. If the pulp is to be coloured the bleaching treatment should be omitted altogether.

2. *Writing paper waste.* This is generally waste such as letters, examination papers or exercise books, etc. Pins, stitching wires, threads, etc., should be removed from the paper. The paper should be torn to pieces. This paper contains water soluble ink used for writing. Hence the percentage of soda used in this case will be slightly more than in the previous case. For white paper it is advantageous to bleach the pulp with 3 to 4% bleaching powder. Except these slight variations the treatment is almost the same as in the above case.

3. *Old books and records.* Such wastes' contain printed or type-written matter. The old records may also be hand-written.

Books are printed with printing ink which is made of fine carbon or soot or mineral pigments ground with an oily medium. Carbon and some pigments have a property of being absorbed by the paper (cellulose) from which the absorbed carbons or pigments cannot be removed by any chemicals. Such wastes should be treated with a slightly higher proportion of soda ash or caustic soda (preferably the latter) to remove the oily matter. The proportion of caustic soda should be between 3 to 4 % and that of soda ash between 5 to 6 per cent. The bleaching powder used should be 5 per cent. The pulps obtained may not be perfectly white in appearance owing to the absorption of the carbon or mineral pigments in more or less proportion as they cannot be bleached.

It should be borne in mind that such waste being old may have deteriorated in quality in which case, they cannot make a fairly strong paper for writing purposes. Such pulps

should advantageously be utilized for blotting paper for which they are well suited.

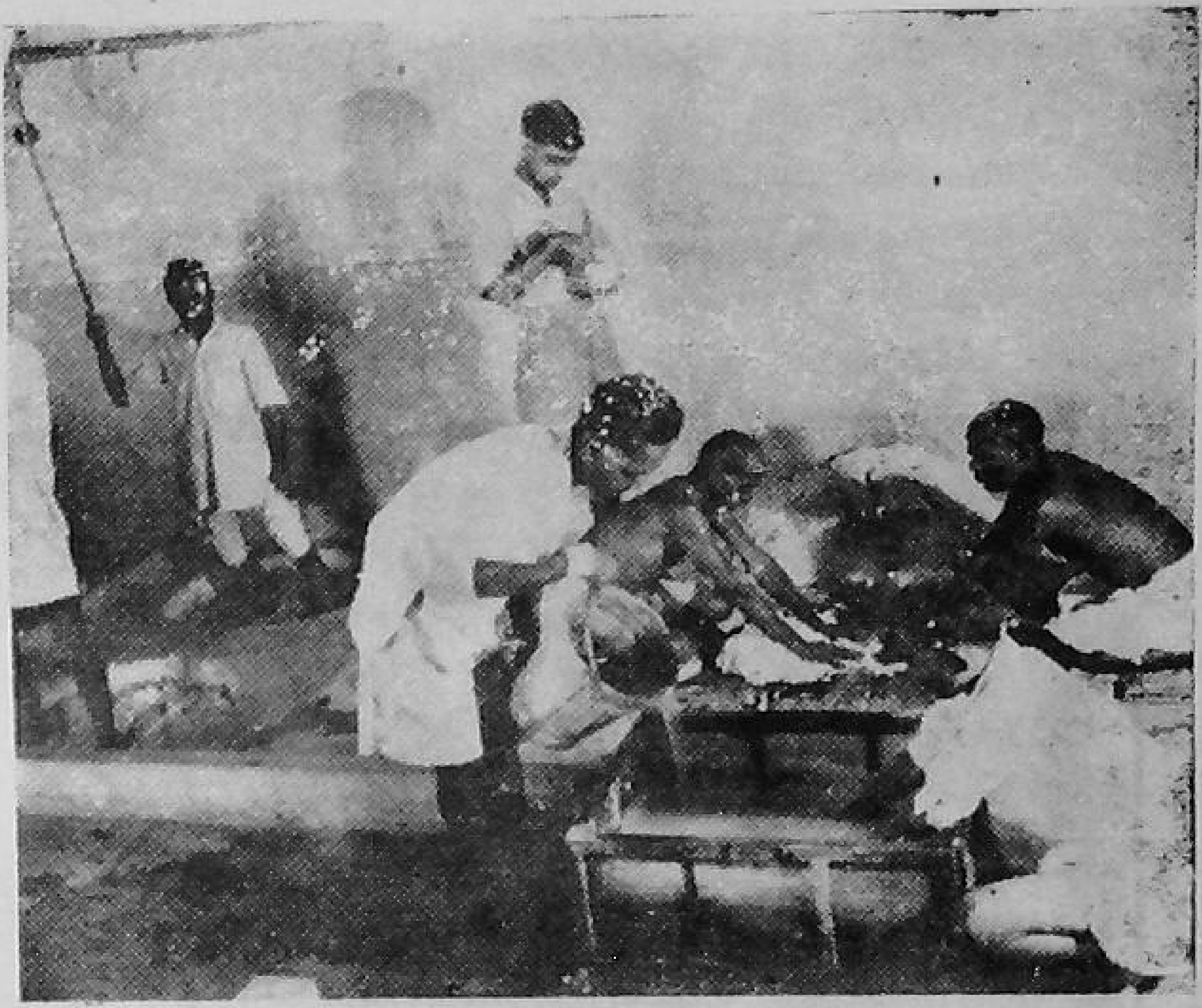
4. *Wrapping paper and similar waste.* This waste may be used for low grade envelope and cover paper. The caustic soda or soda ash used should be about 3 to 5%. There is no necessity for bleaching the pulp.

5. *Office or private correspondence.* In the days of scarcity of paper, such wastes can be usefully converted into paper. The letters may be typed or hand-written. The brown or deep gray covers are not taken for making white writing paper. The other wastes whether letters or covers, white or coloured can be used for making writing paper. They should be treated as for writing paper wastes.

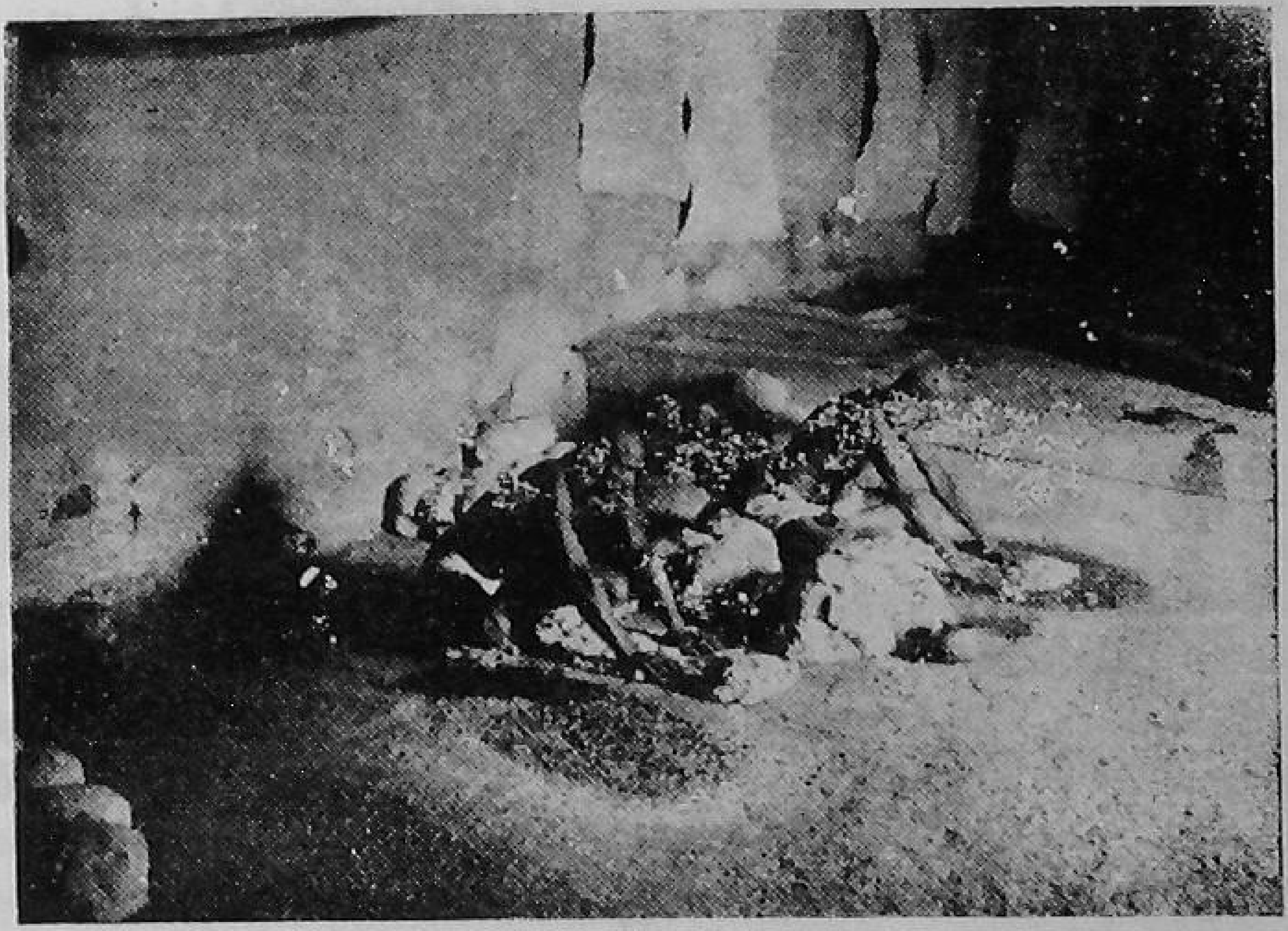
6. *Old newspaper or other mechanical waste paper.* These can only be used in making boards, in which case no chemicals are used. The waste is simply soaked in water and washed and pulped as usual. It is not used for writing paper.

In the case of paper wastes the general process for preparing the pulps is to soak the material in retting tanks with the necessary amount of the caustic soda or soda ash solution, just sufficient to moisten it, for about 3 or 4 days, by which time the sizing is dissolved from the waste. It is then trampled under feet in the trampling pits and washed. The trampling pits are almost semicircular or dish-shaped, the mouth being 28" in diameter and the bottom 12" deep and are constructed with cement concrete or stone. The inner surface is kept rough as thereby the separation of the fibres is easily effected. The trampling pits may also be carved out of stone.

If trampling under feet is found unsuitable the pulps can also be prepared with a wooden pestle and mortar as is used for pounding rice, the beating mallet being somewhat heavier than that used for rice. On a small scale pulps can be made in a stone mortar and peslle as is used for making idly paste in Madras. Afterwards the pulp is rubbed on a rough floor made of stone or cement concrete, till it is finally free from unreduced chits or knots. After washing it may be bleached with a small quantiy of bleaching powder. Sometimes the pulp is also given a soap treatment and washed. Another



Trampling, Rubbing & Washing in a Cradle-basket



Rubbing the pulp

Washing near a tank

method of reducing the waste paper to pulp is to boil it with 5% soda ash or 3% caustic soda with sufficient quantity of water for about half an hour or so and then to leave it overnight. Next day it is trampled and rubbed and washed as usual. This not only facilitates the complete removal of the sizing material but also helps in making good pulp with the least chance of having any unreduced portion in the finally prepared pulp; so also this saves time.

On a small scale instead of trampling, the waste paper after boiling with soda, is churned violently with a country butter churn till it is almost reduced to pulp. Next the water is squeezed out and the pulp is finally made in stone pestle and mortar or rubbed on a chutney stone.

(11) MULBERRY

THE OLD JAPANESE SYSTEM OF PAPER-MAKING FROM THE MULBERRY PLANT. Paper-making was introduced into Japan about 700 A. D. The paper is mostly made from the inner barks (sasori) of the mulberry plant of 6 or 7 years growth. The old branches of the plant are cut in winter as they are then considered best for paper-making. After stripping the leaves which are used for rearing silkworms the stalks are cut and steamed in a boiling tank. The bark is stripped off from the stalks and the remaining sticks are used as fuel. The bark is then divided into small bundles and dried. The bundles are made into small lots of 30 to 32 lbs. each. The lots are then kept in a running stream or river for 24 hours for washing. Afterwards the inner bark is separated from the outer incrustation by scraping with a knife. It is again washed in a running stream. It is boiled in water and pressed to remove the sticky material. The bark is afterwards boiled in a lye of wood ashes or lime. It is again washed in baskets in running water. The sasori is then placed on a table and beaten with a square mallet with a rounded handle. It is again washed and again pounded. Rice paste or mucilage from a plant called toroto is sometimes mixed before the second pounding. The pulp is then heaped into balls which are taken as required. Paper is made from vats called "boats." The paper-lifting frame consists of an inner and

an outer frame, a sieve and a false bottom. The false bottom and the sieve are placed on the outer frame and some pulp is put into it, and the inner frame is placed over the seive and the false bottom to keep them firm over the outer frame. It is now dipped into the boat and the pulp on the frame stirred and jerks are given to set the pulp well to form a uniform sheet. The paper is removed skilfully by a thin bamboo stick and dried in the sun or by fire heat in winter. The paper is variously treated to make paper cloth, rain coats, boxes, sauce-pans, trays and a host of other articles.

Nepal paper is also made in more or less the same manner from a plant of that name. Remeta bark (Lassio cipon Eriocephalus) a plant growing on the Matheran and Sahyadri hills and the Deccan can be converted into similar paper.

CHAPTER VIII

(A) PAPER LIFTING

PAPER LIFTING may be defined as the art of mechanically co-mingling or fabricating or felting together into a continuous web or sheet of fabric, the ultimate or small units of the cellulose fibres which have been reduced to a suitable condition by the process of beating and are suspended in water. From the above definition it will be seen that the quality of the paper will depend (1) upon the way in which the fibres are fabricated or felted together, an operation which depends upon the skill of the vatman. This felting is brought about in a maximum degree by the kagzi giving a to-and fro-motion to the pulp in suspension with water on the mould and thereby intermingling the numerous fibres with one another. If the pulp is taken on the frame without the necessary jerks or rocking movements the paper will be weaker. One of the conditions that make hand-made paper stronger than machine-made paper, is that in the former the fibres are felted together by the vatman from all corners or angles, which is not the case with machine-made paper. (2) The other qualities of the fibres that are essential for good paper are their length and strength, and the felting power of their ultimate units. The nature of the paper will depend on the degree of the qualities possess by its component fibres ; those possessing suitably great length and strength with good felting qualities making the strongest and best kinds of paper and fibres poor in these qualities making the poorer kinds. (3) The quality of the paper also depends up on the manner in which the fibre is beaten to pulp. Rags, flax (linseed stalk fibre), hemp, sunn-hemp, rhea or China grass, Nepal paper plant, mudar or rui bark, fibers of the Nilgiri nettle, etc., make the strongest papers, while bamboo, munj grass, etc., make medium, and sugarcane bagasse, maize and certain grasses make weak papers.

There are four paper-lifting systems (1) Indigenous system of the old artisan class. (2) Modern system of paper lifting. This is a modification of the first and the third system. (3) European system of the present day. (4) Nepalese or Chinese system sometimes followed for paper-making.

(1) INDIGENOUS SYSTEM

IMPLEMENTS. (1) Paper-lifting vats of the old system. (2) Bamboo sticks. (3) Paper-lifting frames with mats of suitable sizes. (4) Two wooden boards about 4'×3½' and ¾ to 1" thick or of some suitable size. (5) Heavy weights or stones, or if possible a screw press.

OLD PAPER-LIFTING VATS. Fig. 6. illustrates the general arrangement of two paper-lifting vats as followed by the old paper-makers. a, b, c, d, is a rectangular floor or ota, made of cement concrete, lime-mortar or stone, about 20 feet long and 10 feet broad, rising about 1½ to 2 feet above the ground. In the plan, 1 and 1 represent two paper-lifting vats which are 5½ feet long, 4½ feet broad at the top and about 3½ feet deep. Their bottom is 3 feet long and 1½ feet broad. These vats are so constructed that the side where the vatman sits is almost vertical as shown at X in the sectional drawing, while the other three sides slope as shown at Y, Y1 and Y2. The corners are rounded so that pulp or any dirt may not lodge in them. The object of this peculiar construction is that when the contents are exhausted the residual pulp left may not be great. Besides, any sand or nails that may have accidentally lodged in the pulp will settle to a small bottom, facilitating their removal. This slope also helps better stirring of the pulp. The object of making the side in front of the vatman almost vertically straight as shown at X, is for the free movement of the frame in the vat while he is working it for paper-lifting; otherwise it may obstruct the frame. If the sides are not sloping too much (*i.e.*, when the bottoms are wider than those shown in the illustration) then the paper can be lifted from any side. The brims of the vats are raised by about one to two inches above the level of the floor, so that no dirty water may enter into them. The inner sides of the vats must be smooth as otherwise the pulp will lodge in the crevices when it might be difficult to remove it and clean the vats. All the corners are rounded for the same reason.

In the plan, the position of that vat which is nearer the side ab, is about 2½ feet distant cistant from the side ad & about 4 feet from the side ab, while the other vat is adout 3½ feet

from the side ad and 2½ feet from the side cd. The two circles marked 2 in the plate are cylindrical tanks or kundis about 2 feet in diameter and 1½ feet deep. They serve either for storing the pulp or for mixing it with water or any colouring or sizing material by trampling or stirring. The vatman sits at places marked 3. The spaces marked 4 are for piling the wet sheets. They are about 4½' long and 3½' broad, sufficient for easily manipulating the operations of couching the wet sheets in layers and pressing them to squeeze out water from them.

A1 A represents a sectional diagram of the vats through positions marked by a broken line shown in the plan from A1 to A. The dotted rectangles in the plan at 1 show the battam and the dotted slant lines show the corners of the vats, which should be rounded; the double rectangles show the tops of the vats, which are in the level with the ota, but which should be brimmed by about 1 or 2 inches above the level of the ota or floor. In the sectional drawing, the portion shown by the hatched lines represents the floor above the ground. The vats are shown sunk below the ground level. This arrangement of the vats is only useful for lifting paper from a sitting position according to old kagzi style.

Construction of Paper-Lifting frame and mat. The mat is first constructed as illustrated in Chapter XIII on mat-making. In making the mat the following points are taken into consideration, namely, the size of the paper the shrinkage in the sheet in drying, the rough edges required to be cut and the size of the round and fiat wooden bars which form the deckle on the mat on wich pulp is taken for sheet formation. Thus the size of the mat whill be :—Length = Length of the paper + 2" for the shrinkage and cutting + 3" for stitching the two round bars at the ends and for making the zum on the wet sheet. Breadth of the mat along the stalk line will be equal to the breadth of the paper + 2" for shrinkage and cutting + 2½" for placing the two side-rectangular bars each 1¼" in width. In the case of small size paper the margin for cutting should be 1" to 1½" instead of 2". The deckle bars may be 1" instead of 1¼". The ends of the mat

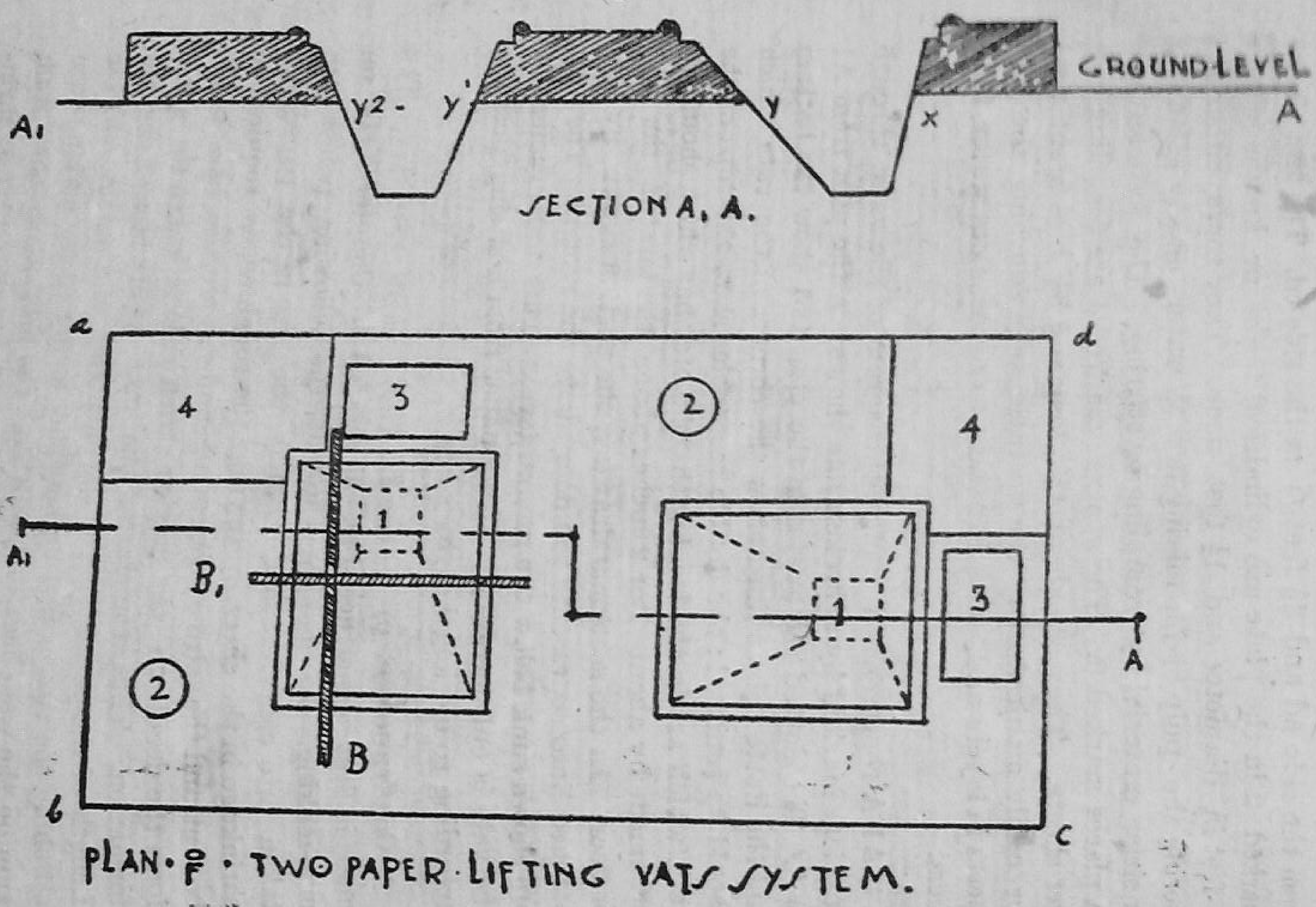

GROUND LEVEL
A
A1
y2 -
y'
y
x
SECTION A, A.
a
d
b
c
4
3
2
1
B,
B
A1
A
PLAN · OF · TWO PAPER · LIFTING VATS SYSTEM.

Fig. 6

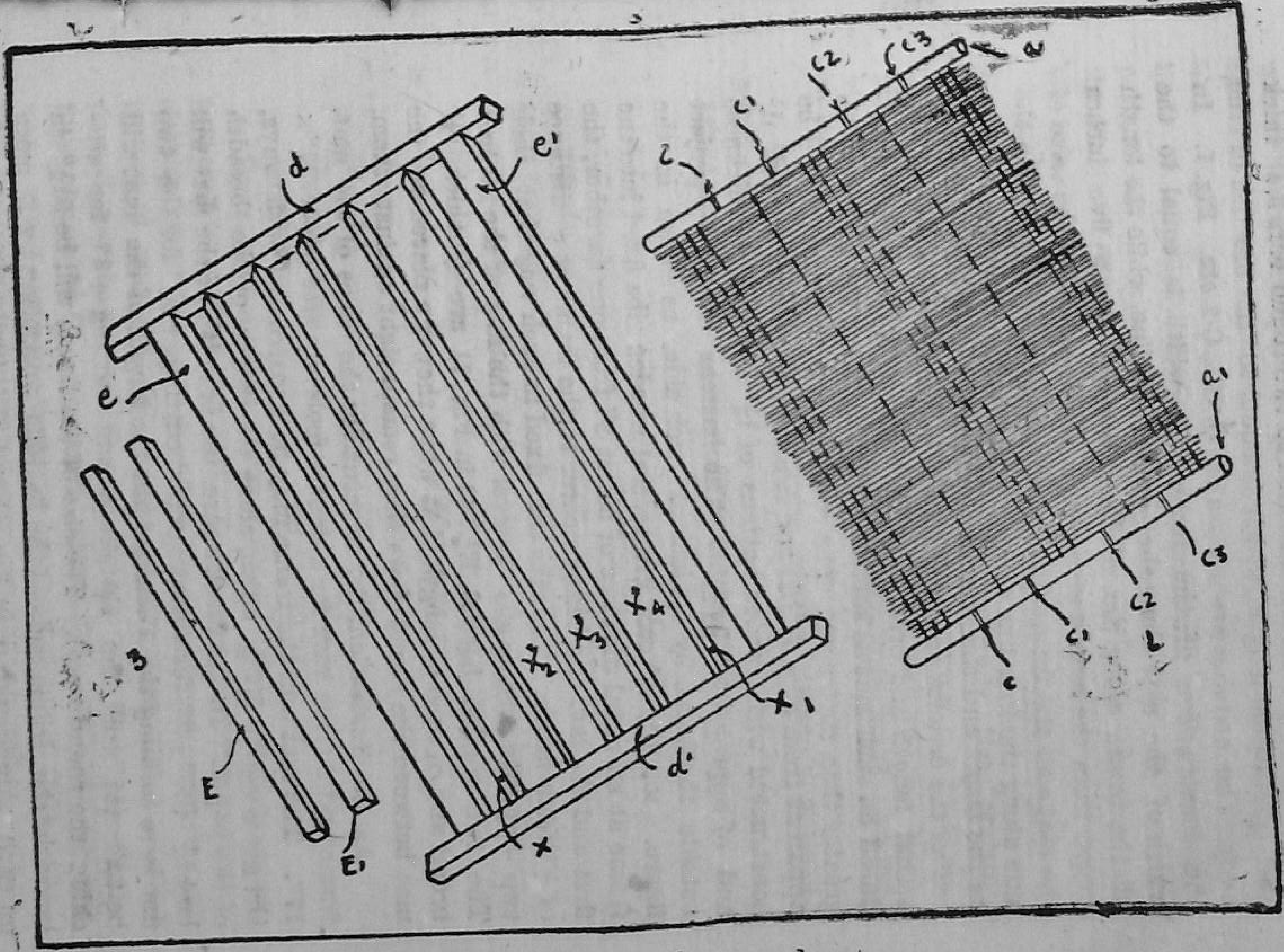


Fig. 7.—Old paper frame and mat

along the stalk lines are stitched to two round bars 3/4" thick and of suitable length, which is equal to the breadth of the mat. The stitches are shown at C, C-1, C-2 etc. Fig. 7. In the construction of the frame, its width is equal to the width of the mat along the grass stalk line, while the length of the frame along the rib lines is made four to five inches longer than the length of the mat. In considering the size of the mat and the frame for the convenience of description the side along the hair line at right angles to the stalk line is taken as the *length* and the side along the grass stalk line is considered as the *breadth* or the *width* of the mat irrespective of the actual length and breadth of the mat or the paper to be produced on such mat as sometimes the width of the mat may be greater than its length. The construction of the frame will be apparent from Fig. 7. There is an outer frame e, e^1, d, d^1 constructed with wooden battens of $1\frac{1}{4}$" width $\frac{3}{4}$" in thickness and of appropriate lengths. The battens d and d^1 project outside the frame by an inch at each side, as shown in the figure. $\times$, $\times^1$, $\times^2$ etc., are several wooden ribs fixed into the frame at an equal distance of about 2" from one an other, the first and the last one being nearer to the frame at a distance of $\frac{1}{2}$" from inside. The ribs are fixed in such way that their two opposite corners are in level with the face of the frame. The two wooden bars E, E^1. (3 in Fig. 7) are $\frac{3}{4}$" thick $1\frac{1}{4}$" broad and of such a length that when they are placed on the mat between the round bars they remain tight against them,

As an illustration, let us consider the sizes of the mat. frame and 2 loose bars for a double fools-cap size paper 27"× 17". The mat and the frame may be constructed both ways, the grass stalks lying either along the length or the breadth of the paper. In the former case the breadth of the mat will be $31\frac{1}{2}$" (27"+2" for shrinkage and cutting +$2\frac{1}{2}$" for the two flat bars forming the deckle) while the length of the mat will be 22" (17"+2" for shrinkage and cutting +3" for stitching the round bars). The size of the frame will be $31\frac{1}{2}$" in breadth, the frame ends of the battens projecting by 1" more on each side (See d, d' in Fig. 7) and 27" (22"+5") in length along the rib line. The number of the ribs will be 10 or 11. The two loose side battens forming the deckle on the mat

will be about $19\frac{1}{2}$" to 20" × $1\frac{1}{4}$" × $\frac{3}{4}$" thick. In the latter case the size of the mat will be $21\frac{1}{2}$" (17"+2"+$2\frac{1}{2}$") along the hair stalk line and 32" (27+"2"+3") along the line. Consequently the size of the frame will be $21\frac{1}{2}$" with 1" projections on each side as at d, d' and 37" (32"+$2\frac{1}{2}$") along the rib line. The number of the ribs will be 6. The size of the loose bars will be $29\frac{1}{2}$" to 30" × $1\frac{1}{4}$" × $\frac{3}{4}$".

The measurements of the frame are taken from outside.

By following these principles carefully the frames and the mats can be made for paper of any size. It must also be noted that the stalk lines of any mat are at right angles to the ribs, of the frame, the hair lines being parallel to them.

The following are the sizes of the different finished papers:—

Kind of Paper	Size of the finished Paper in inches
$\frac{1}{2}$ foolscap	$13\frac{1}{2}$ × $8\frac{1}{2}$
1 foolscap	17 × $13\frac{1}{2}$
2 foolscap	27 × 17
4 foolscap	34 × 27
Single letter-head	$11\frac{1}{2}$ × 9
Shahistekhani	28 × 21
Bahadurkhani	38 × 31
Demy	$22\frac{1}{2}$ × $17\frac{3}{4}$
Royal	25 × 20
Double crown	30 × 20
Imperial	30 × 22

PREPARATION FOR PAPER-LIFTING. Pulp having been prepared in sufficient quantity for the vat, is first put into a circular kundi or cistern (see 2 in Fig. 6) in which some water is poured and the pulp trodden under feet. This is then poured into the paper-lifting vat which has been previously filled almost to the brim with pure and clean water. If the water is not clean it should be strained through cloth. The pulp is now stirred with a bamboo stick for a sufficiently long time to distribute it uniformly, breaking any lumps and separating the individual fibres. The quantity or concen-

tration of the dry pulp in the water should be between 1 to 2%. The mixture should be sufficiently thin for proper lifting of the paper. After vigorous stirring, the pulp is allowed to settle at the bottom for some time.

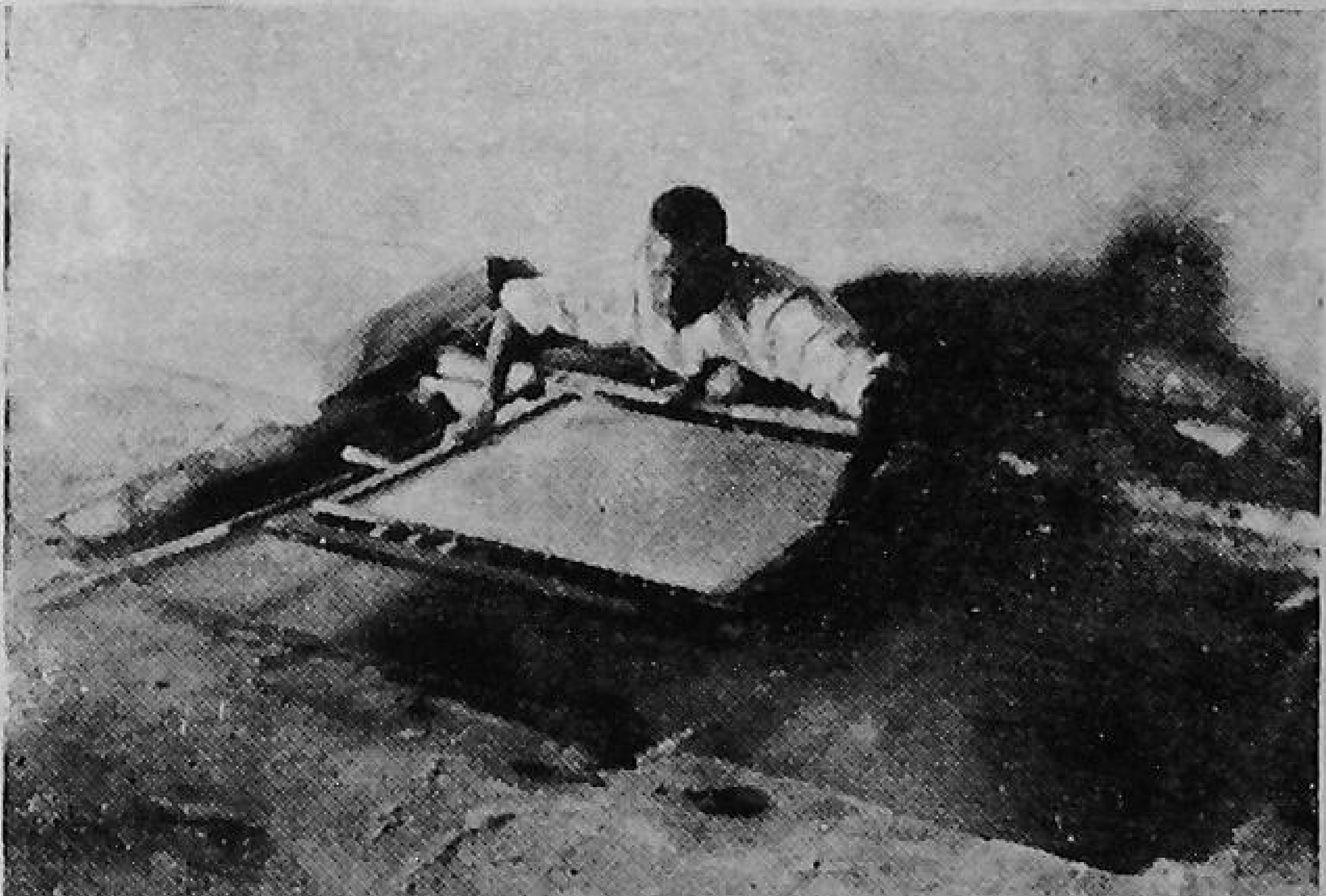
VATMAN'S OPERATION—OLD SYSTEM. Next the process of paper-lifting commences. The vatman sits at a place (marked 3 in Fig. 6) facing the vat and places two bamboo sticks B and B_1 across its length and breadth and at right angles to each other. (See their respective positions over one of the vats. Note also that the bamboo B_1 is placed over the bamboo B.) Next he takes the frame and places it in such a way that the horizontal side d_1 (Fig. 7) rests on the ridged brim of the vat in front of him while the other side d rests on the bamboo B^1 (Fig. 6).

He then places the mat on the frame in such a way that the grass stalks are at right angles to the ribs of the frame, the horse hair or chain lines being parallel to them. He then takes the two wooden bars and stirs the water in the vat just to bring some of the pulp to the surface. The bars are now quickly placed on the mat in such a way that with the round bars they form a rectangular shallow basin or deckle in which the pulp is taken to form the sheet.

Afterwards he raises the frame from the opposite side and quickly removes the bamboo B^1 and places it aside, so that it may not obstruct the operation of lifting paper. The vatman next holds the frame in his hands in such a way that his thumbs and fore fingers press against the two loose rectangular bars while the rest of the fingers press the frame from underneath.

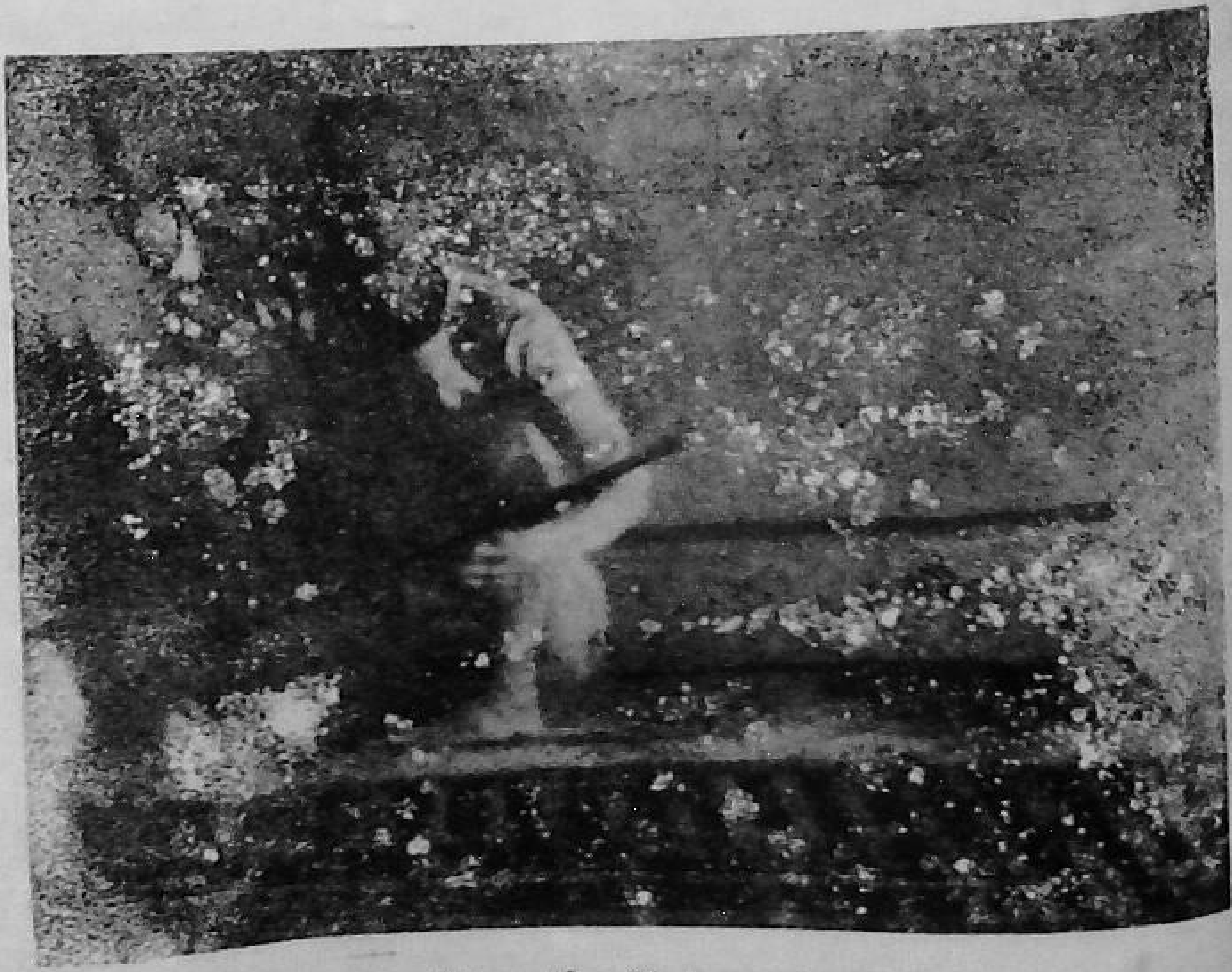
Next he dips the frame almost vertically into the vat and turning it horizontally in his hands, takes some of the pulp on the mat and brings it to the surface of the water and immediately begins to level it on the mat by shaking it to and fro. Any excess pulp is allowed to flow away from the opposite side of the frame. This requires judgment on the part of the vatman. While the water is draining away from the pulp he gives to and fro vibrating motions to the frame. At the same time the two thumbs gently strike against the

Stirring the pulp



Paper lifting-Old system

Vatman making zum



After couching, the Vatman in the act of replacing the mat

two loose rectangular pattis. This vibrating of the frame is done from all sides or directions. This helps to felt or intertwine the individual fibres in the pulp, making the paper strong. He then carefully lowers the frame in its horizontal position just a little into the water and floats the pulp layer on the mat from all sides, and by giving slight jerking motion here and there adjusts the uniform thickness of the paper layer. If he wants a thicker paper he then repeats the process of taking out another layer of pulp over the first one and all the subsequent operations of vibrating are done as before. This is called double layering of pulp, or in the vatman's terminology. "Do panika kagaz." This double layering gives additional strength to the paper. This system is also followed in case the quantity of the pulp in the vat is less, thereby making the sheet of the required thickness.

Afterwards he raises the frame, and resting it on the brim of the vat quickly replaces the bamboo B in its original position, and places the opposite side of the frame resting on this bamboo. The two loose rectangular pattis are then removed and the wet sheet is given a fold called "zum" from the opposite side by turning the mat by about 1/4 of an inch and pressing it with the round bar. This facilitates the easy separation of the wet sheet from the mat. He then raises the mat with the pulp layer on, from the side in front of him with his right hand and holding the opposite or zum side with the left hand couches the wet sheet on a piece of cloth or an old mat over a wooden board. The sheets are generally piled at the vatman's right hand. (See 4 in Fig. 6.) After couching the wet sheet, he squeezes out some water from the sheet by lightly pressing the mat with his hands and then detaches it from the wet sheet by raising it quickly from the zum side without injuring the sheet. If at some place it is found difficult to separate the layer of wet paper from the mat, he replaces it over the layer and sprinkles some water over it at that portion and again tries to squeeze out of the water by moving his hand over the mat round about the non-separating portion, and again raises it to separate the paper layer.

After thus placing the wet paper on the wooden board the vatman replaces the frame and the mat over the vat as

before and repeats the operation of paper-lifting and couches this second paper layer over the first one. Sometimes a piece of cloth of sufficient length is placed between the two wet sheets of paper.

The performance of lifting the sheets from the pulp in the vat and couching them on the wooden board is a dexterous one, taking only one to 1½ minutes on an average for each sheet.

The vatman must be skilled. Not only must he lift a sheet in about 1 to 8½ minutes, but he must have sufficient judgment in taking the pulp over the mat to produce a uniformly even paper of the desired thickness. The skill is acquired by practice and constant observation.

When a sufficient number of sheets generally 120 or 240 are piled one over the other, a piece of cloth is put over them, and then a wooden board of sufficient dimensions is gently placed on top of it. Some of the water is squeezed out by pressing the upper board slowly with the hands and as the water is squeezed out some stones are placed one after the other at intervals and thus most of the water is removed from the paper. This pressing of the paper for squeezing out water either by hand or with stones must not be sudden by putting the human or stone weights all at once, but must be gradual as otherwise it will injure the paper.

Next the paper is separated gently sheet by sheet, taking care that it is not broken and pasted or struck on the wall for drying by means of a soft brush.

If a rumal or piece of cloth is placed between each wet sheet of paper, the paper layer together with the rumal is stuck on the wall with a soft brush, the paper sticking to the wall and the cloth forming the outer cover. The cloth is removed after it is somewhat dry, leaving the paper on the wall, till it is completely dry.

The wall used for drying the paper should be plastered with lime-mortar and must have a perfectly smooth surface as otherwise the wet sheet may get holes or the sheet may not properly stick to it. Experience has shown that cement plastered walls are not well suited for drying the wet sheets.

Sometimes they stick hard over such surface even after drying and they cannot be separated without tearing them. This is especially so when the pulps are sized with rosin or pulps are long fibred.

If a screw press of suitable size is available, then the wet sheets should be pressed in it to remove most of the water. The sheets are then separated from the cloth and repiled into a regular heap without any piece of cloth between them. This heap is gently squeezed a second time in the press to remove more water from it. The wet sheets thus freed from most of the water are separated and dried on ropes or pieces of smooth bamboo. In order to save space 2 or 3 sheets which are previously separated from one another may be hung on the ropes or bamboos. This does away with the necessity of having a smooth wall.

The dried paper is then collected and lightly rubbed with a rough stone such as pumice stone or a piece of unglazed tile to remove any knots or raw fibres etc., from the surface.

(2) Modern system of Paper-lifting

In modern practice the sheet is made by the vatman standing in front of the vat as against the old system of sitting by its side. The apparatus required are (1) a wooden or cement vat, (2) a moving table, (3) an ordinary table, (4) a towel horse. (5) paper making frames, (6) pieces of cloth or felts, (7) bamboo or wooden sticks, (8) couching boards, (9) stone weights as in old system or a screw press.

The vat-room arrangements. (See Fig, 8, 9—Plate 6) The vat V receives the pulp from which the sheets are to be made. It is constructed either of wood or cement concrete. It is $4\frac{1}{2}' \times 3\frac{1}{2}'$ at the top and 3' vertically deep. The two long sides, immediately in front of and opposite the vatman V, slope equally towards the base by 6" on each side, the other two sides being vertically straight. Thus the base of the vat is $4\frac{1}{2}' \times 2\frac{1}{2}'$. In case of the wooden vat, the planks should be 1" thick. The planks are joined together by tongue and gorove method. The joints should be filled either with zinc paint, wet pulp or plantain fibre to make them water-tight. The corners should be rounded to prevent lodgment of pulp. Thick wooden battens are screwed outside the top of the vat to have

a broad surface. Battens 3' long $1\frac{1}{2}$" square are screwed inside the vat at a distance of about $1\frac{1}{2}$" to 2" from the upper edges of the longer sides of the vat. These serve as rests for one side of the paper-lifting mould. A Wooden or bamboo stick S rests freely on the top of the vat and serves as rest for the other side of the mould. An ordinary table T, at the vatman's left hand side receives the frame from the coucher C after couching the paper. The wheeled table T $3\frac{1}{2}$' × 3' × 3' high lies at the right hand side of the coucher C, while the towel horse H rests on his left.

Sheet formation. The men required are (1) vatman V (Fig. 9) who makes the sheets, the coucher C who assists the vatman in spreading the cloth over the wet sheet on the frame and couches the sheet on the couching board B, and 2 assistants who press and dry the sheets.

Procedure. The vat is filled about three-fourths with water and the necessary amount of the pulp is poured in and the final volume of the liquid is made with more water. Generally the vat is filled 3" to 4" from the top. The concentration of the pulp in the vat is generally 1 to 2 per cent. The vat described in this book holds from 20 to 25 lbs of the pulp. The pulp is then stirred with a bamboo stick so that the fibres move freely without any lumps. It is then allowed to settle at the bottom. The paper-lifting moulds used in this system are either the old type frames with grass mats or moulds laid with wire cloth with corresponding deckles or moulds laid with laid bronze wire. In the first case two grass mats to each frame and in the other two cases two similar frames to each deckle are used.

Construction of the wire gauze mould and the deckle. The frame and the deckle are of the same size and are so constructed that the wet sheet formed inside the deckle on the frame is greater by 2" each in length and width of the paper to allow for the shrinkage and cutting the sheet into proper size. The frame and the deckle are made of seasoned teak wood or mahogany battens $\frac{3}{4}$" thick and 1" to $1\frac{1}{4}$" broad and of suitable lengths. The frame is fastened with two ribs horizontally and vertically, somewhat similar in appearance

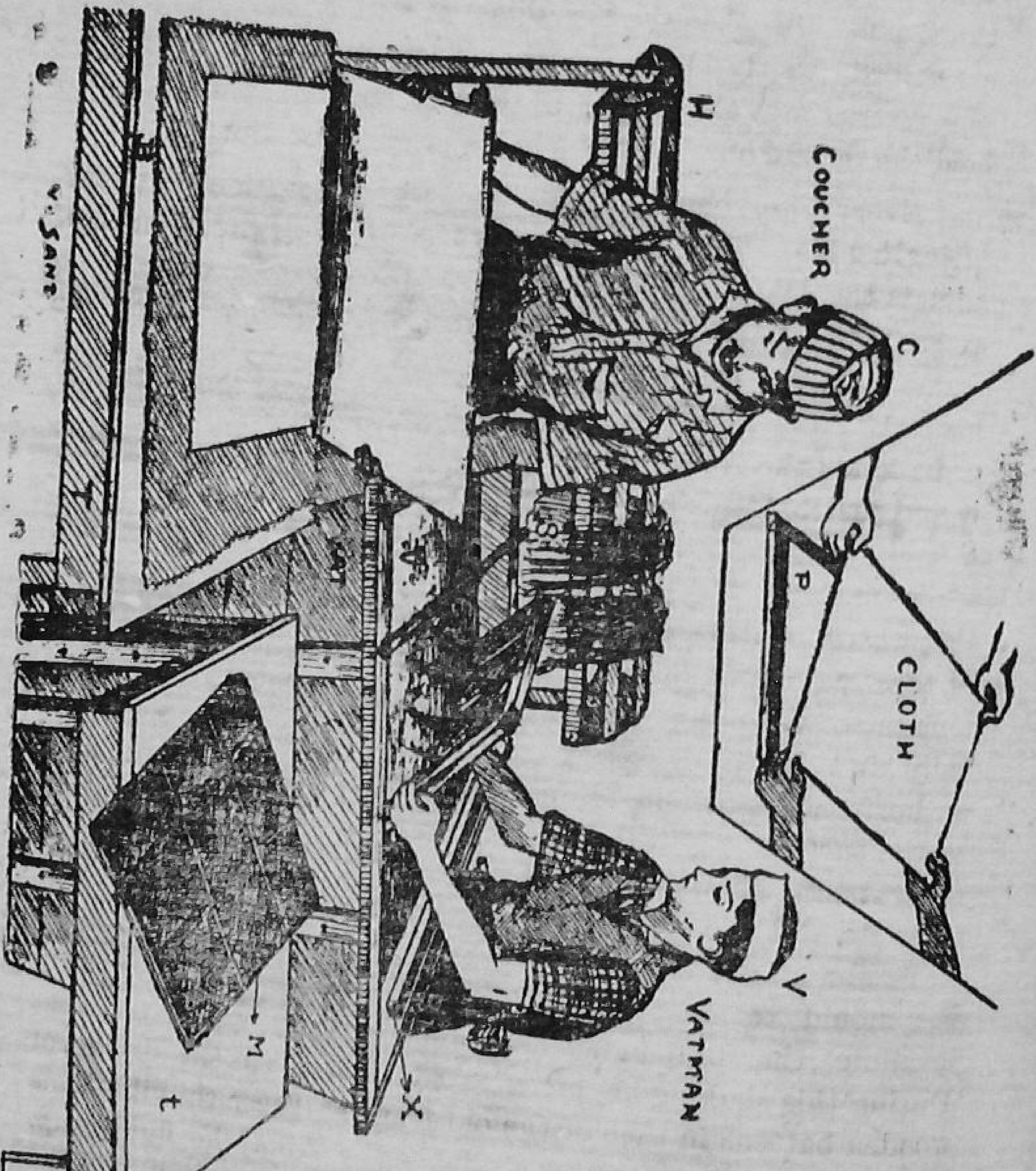
Plate 6.—Modern paper lifting and couching

Sheet Lifting
Students under training

to the deckle frame illustrated at B in Fig. 12. These ribs are not in level with the face of the mould on which the gauze is laid, but are at a distance of a quarter of an inch from it. Wove wire cloth of 40 meshes to an inch is laid tight over the frame. In the shorter sides of the frame small holes are drilled exactly in the centre. These serve as slots to the pins riveted into the deckle at the corresponding places. These hold the deckle on the frame in its proper position.

Everything being ready the actual operation of paper-lifting begins. The vatman takes the paper-lifting frame and adjusts the dekcle on it while it rests on one of the batten stays X and bamboo sticks S. The vatman now raises the frame with the deckle on, by the side opposite to him, with his right hand and pushes the stick S back with his left hand, or he holds the frame in the middle with his hands and raises it and just before dipping it into the vat pushes the stick S back so as not to obstruct the movements of the frame while making the sheet. Then he stirs the surface of the water gently with backward and forward movements of the frame and just bring to the surface, the requisite amount of the pulp. He then dips the mould almost vertically and by a dexterous performance turns it almost in an horizontal position taking some pulp on it and brings it to the surface. If the pulp is in excess of the requirements the vatman allows the excess pulp to flow away from the opposite end by a slight tilting motion. The mould all the while almost floots on the surface. The vatman then shakes the mould to and fro, horizontally and vertically, thereby levelling the pulp on the mould to unifrom thickness. During this shaking he gives rapid strokes to the deckle or wooden battens in case of the old frames. These set vibrations in the pulp while the water drains away from the fluid pulp. The result is that the fibres are well felted from all directions. While the water drains aways the pulp assumes a peculiar appearance on the frame. It will also be noticed that the water from the mid-portion drains away last. After most of the water has passed away the vatman raises the mould upward and resting one of the sides on the batten stay X in the vat quickly draws the bamboo towards him and causes the

Fig. 9—(Modern vat room arrangement)



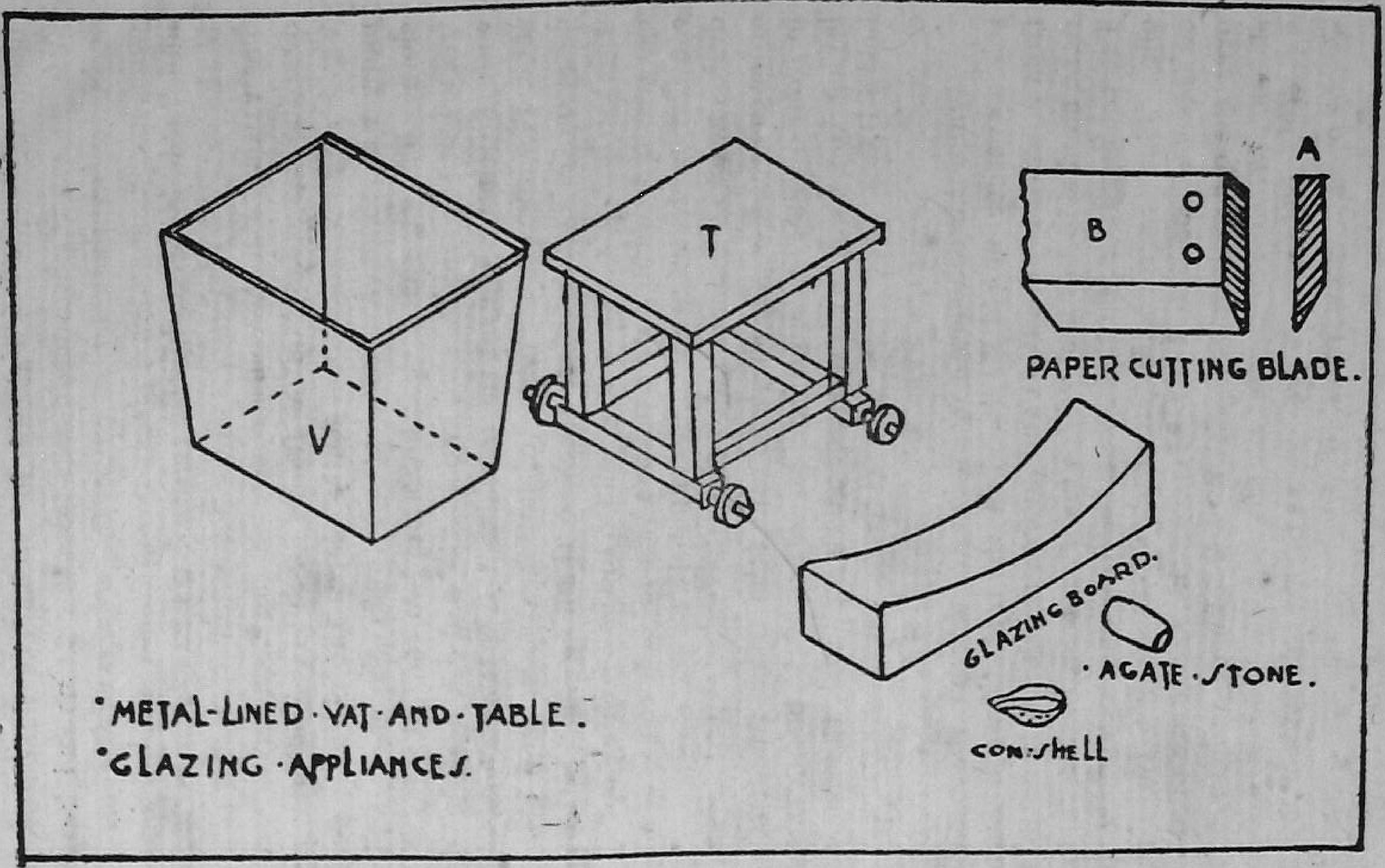

V
T
B
A
PAPER CUTTING BLADE.
GLAZING BOARD.
· AGATE · STONE.
CON: SHELL
· METAL-LINED · VAT · AND · TABLE.
· GLAZING · APPLIANCES.

Fig. No. 8

other end of the frame to rest over it or the coucher pushes the bamboo towards the vatman for resting the mould over it. The vatman removes the deckle from the frame and keeps it to his left overhanging on one of the corners of the vat. The coucher next snatches a piece of cloth from the towel horse H and holds it firmly by the corner ends and swings it forth to the vatman who grasps the opposite corners with his hands. The vatman and the coucher stretch the cloth and spread it over the wet sheet P on the frame. (See the inset drawing in Fig. 9). The vatman next gently places the cloth in such a manner as to leave no air spaces between the sheet and the cloth. The coucher C next holds the two vertical sides of the frames in the middle with two hands and couches the sheet with the cloth on, over the couching board B on the wheeled table T. Five or six pieces of cloth are spread one over the other on the board before couching the first wet sheet, otherwise the first few sheets are spoilt. In the couching operation the frame with the cloth and the sheet in between is carefully couched on the table and pressed lightly by the coucher. This drains away some more water from the sheet. Afterwards in order to separate the sheet he raises the frame from the side in front of him, the opposite side resting on the board, thereby laying the cloth with the wet sheet on, over the couching board B.

While the couchers's operation is going on, the vatmam seizes another mould M placed on the table t by the coucher from a previous operation and puts on the deckle lying on his right hand side and proceeds to make another sheet as before. The coucher lays the sheet together with the cloth on the first one. Thus the cloth lies alternately between the two sheets on the couching board. In this way the sheets are piled one over the other alternated with a piece of cloth in between the sheets. When 120 sheets are formed the pile is called a "Post". This post is pressed as in the old system by the weight or in a screw press, to remove excess water from the wet sheets. The 2 assistants now separate the sheets with the cloth on and stick them on the wall for drying. The sheet lies between the wall and the piece of cloth. Sometimes

for the sake of convenience small posts of 30 sheets are pressed to squeeze out the water.

When the sheets are partially dried, the pieces of cloth are removed and sent to the towel horse H for re-use. The partially dried sheets are taken away from the wall and dried on the ropes. During this drying the paper shrinks somewhat.

Every time a sheet is formed the concentration of the pulp in the vat becomes less and less. Hence at suitable intervals fresh pulp is poured into the vat and stirred as before.

The work of the vatman and coucher must be in tune for good efficiency. In this system an average vatman is able to make about 500 sheets during eight hours, (the actual working hours at the vat being six) while a skilled vatman is able to make more than 100 sheets per hour. The quantity of well made sheets in a fixed time also depends upon the quality of the pulp, whether wet, beaten or free. In the former case the number of sheets made are less. In the old system the number of sheets made are only 240 in 8 hours. Moreover the vatman in the old system has constantly to sit at the vat in an awkward position causing strain on his chest and at each sheet formation he has to bend at the vat and change his position in couching the sheets. All these troubles are avoided in the modern system. Paper can also be made from this vat according to the old style of sheet-lifting and couching by standing at the vat.

(3) European System of Paper-Lifting

The general construction of the vats is similar to that described in the modern system except that they are more spacious. The size of the vats is 5' square at the top and 4' deep. They are constructed either of stone slabs, or wood lined with copper sheet from inside.

The paper-making moulds are more elaborate in construction. The frame is constructed of seasoned mahogany wood. Thin V shaped ribs made of oak wood are fastened to the longer sides of the frame at a distance of 1" to 1¼" from each other, corresponding to the chain lines of laid wires on the mould; the sharper edges being in level with the upper surface, and the broader edges towards the bottom. The

depth of the ribs is somewhat less than the depth of the outer frame The ribs are also drilled with numerous pin-holes which serve to stitch the upper wire coverings. 2 or 3 stiff brass bars, $\frac{1}{8}$" in diameter pass across the ribs right into the shorter sides of the frame. Then the wire coverings are fixed on the mould. There are two systems of covering the mould; one is called the "laid" and the other, the "wove" system. The laid covering produces laid and chain lines as water-marks in the paper as with the grass mat, while in the wove system no such water-marks are produced in the sheet. For laid wire mould and the deckle (See Fig. 11 infra).

In the laid system a back covering is prepared with thick laid wires (16 No. gauge) generally numbering 9 to 10 to an inch stitching of sewing them at equal distances of 1" to $1\frac{1}{4}$" apart corresponding to the thin ribs. This backing serves as a support to finer laid covering which is made of thinner wires (24 or 25 gauge). Wires in the upper covering are 22 to 24 in number per inch. They are stitched at eqnal distance apart corresponding to the ribs and the stitch lines in the supporting back covering. When the two coverings are made the course wire covering is first placed over the ribs. Thin but hard wires are placed along the stitched lines of this covering, over which the finer covering is laid. The two coverings with the thin hard wire in between them, are finally stitched with the ribs with wires as thin/as hair. The stitched (chain) lines of the coverings and upper edge of the ribs must corresdond with each other. This final stitch with the woven thin wire lines produce what are called chain lines as water-marks into the paper, the laid wires producing the "laid lines at right angles to the chin lines" in the sheet. These correspond to the grass and hair lines in the old mat.

In the wove system instead of the specially made laid wire coverings, a coarser (16-20. No.) and a finer wire cloth (40 to 50 No.) are used, the latter on the top of the former. They are stitched to the ribs at a distance of 3/4th to 1" apart. No water-marks of the uppor covering are produced in this system as in the laid system. Any trade marks in

letters or designs are stitched or soldered over the top coverings in both the systems to produce the desired water-mark.

The edges of the coverings either laid or wove are secured on the frame by small strips of copper sheet riveted with copper rivets on all the four sides. The laid or wove coverings are made of bronze or copper. The deckle corresponds to the mould in size being somewhat broader and rounded at the top with a peculiar shape (See fig. 11). There is a grove inside the deckle on all four sidas at the corresponding position of the copper strips used to secure the coverings. These strips lie inside the grove of the deckle when it is adjusted to the frame. The inner size of the deckle corresponds with the size of the sheet to be made, allowance being made for the shrinkage of the paper which is about $\frac{1}{2}$" to a foot. All the corners of the frame and the deckle are secured by metal strips.

The pulp is supplied to the vat from a storage tank known as stuff chest which is situated at a higher level. The pulp first goes to a bucket pump from which it is lifted to the strainer to remove knots, before it finally enters into the vat.

The system is so arranged that the pulp in the vat is always at the same level and concentration. The settling of the pulp at the bottom of the vat is prevented by a stirring devise called a hog. This hog moves at a very slow speed. The operators at the vat are three in number. 1. Vatman ; 2. Coucher, 3. Layman. The vatman makes the sheets in almost the same manner as in the other systems with this difference that he does not float the mould on the surface of the water after taking the pulp on it but raises it above the vat before giving shakes. So also instead of cotton cloth, special felts are used to couch the sheets. They are not spread over the wet sheet but on the couching board over the table. The vatman only makes the sheets. The coucher spreads the felts on the couching board and couches the wet sheets on them.

The felts give a better finish to the paper. When a post of 120 sheets is made it is pressed in an hydraulic press with considerable pressurse which removes a large portion of the water. The post is then removed from the press and the sheets are separated from the felts and again piled in a

heap. This is again subjected to hydraulic pressure. This further removes more water. The sheets are then again spearated and re-arranged and again pressed. This gives an even texture to the paper. The workman who separates the sheets from the felts and re-arranges them is called a layman. The sheets are then hung on the ropes to dry. This is known as loft-drying. The drying room is maintained at constant temperature and humidity. During this process the paper shrinks which increases its strength. Hand-made paper is always dried at a low temperature in order to retain its strength. The finished paper is not cut but its deckle-edge is preserved.

The vatman is a skilled operator. He is given a training of several years before he is considered fit for the job. His muscles are so trained that he is able to make each sheet exactly of the same weight and of the same thickness. He is able to make at least 2 reams of paper per day. (For further details refer to section 2 of "Manufacture of Pulp and Paper" Vol. 5, published by Mc Graw-Hill Book Co.)

(4) OLD NEPALESE OR CHINESE SYSTEM OF PAPER-LIFTING

This system differs from the other three systems described before, in that the pulp is not put directly into the vat from which a layer of pulp is taken on the mould, but a measured amount of the pulp is poured on the mould. The vats are rectangluar but are shallower than those described before. The mould may be made as usual but the deckle should be somewhat deeper.

The vat is filled with water and the mould with the deckle on, is partially suspended into the vat. A measured amount of the pulp previously diluted with water is poured on the mould and stirred gently so as to make it uniformly distributed throughout the mixture. It is then lifted out of the vat. In doing so great force is required owing to the vacuum created under the mould. This causes suction of water from the pulp. The shakes may conveniently be given after the mould is raised. The other processes of couching, pressing etc., are the same as described before. In this system it is

possible to make sheets of even thickness and weights by adjusting the quantities of the pulps added to the mould. But this method is not convenient as it is laborious and would mostly be useful for thicker varieties of paper. Besides it would require considerable practice in uniformly distributing the pulp over the mould.

This method was followed in old days in Nepal, China and Japan.

(B) SHEET DRYING

(1) *Drying on the walls.* This is the simplest and most convenient method of drying the wet sheets. The walls whether they are in brick or in mud and stone are plastered with ½ inch coating of lime mortar. The surface is made smooth by rubbing with a trovel or a piece of wooden board. The wet sheets with or without the cloth on as the case may be are stuck on the wall, in the latter case with a grass brush or in the former case by pressing it against the walls with hands. The pieces of cloth are removed when the sheets are semi-dry and are re-used. This economises cloth. The sheets after drying are detached from the walls.

In this system the sheets remain flat and after they are dried, no difficulty is experienced while glazing.

If the wall surface is not sufficient then the sheets may be removed in a semi-dry condition and put on bamboos or thick ropes to complete the drying process. The paper will somewhat shrink which is an advantage as it increases its strength. (2) *Drying on ropes or bamboos* :—The best method of drying hand-made rag paper such as bond, drawing etc., is to press the wet sheets in a powerful screw press. The sheets are then separated from the clothes and again pressed. They are again separated from one another and re-arranged in such a manner that their respective order in the pile is changed every time before pressing. This is repeated 3 or 4 times, till all the sheets have a uniform texture and are almost dry to touch. The sheets are then separated and put on the ropes for drying. In order that they may not dry unevenly resulting in cockling, they are dried on ropes in a pile of 5 or 6 sheets so that they dry slowly. The advan-

tages in this system are that the sheets have a unifrom texture and being well pressed the bulk of the paper is reduced making it more dense and compact and besides it gets natural shrinkage. All these contribute to increase the strength, feel and texture of the paper. The other methods are (3) the ends of the clothes with the wet sheets on, are tied to bamboo frames. On drying the sheets are separated from the clothes. (4) Or the sheets are stuck on the galvanized iron sheets in frames instead of the walls.

In this last case; sometimes the colour from the coloured papers is reduced with blistered appearance on the surface of the sheets. But after their use for sometime they do not show this phenomenon which is due to the action of zinc on colours.

In hand-made paper no artificial means are used in drying the sheets but they are allowed to dry in a natural way at low temperatures.

(C) WATER-MARKING

If a sheet of paper made on a grass mat is held against the light, it will be seen that there are transparent lines in the horizontal and vertical directions corresponding to the grass and hair lines in the mat. These transparent lines are produced by the difference in the thickness of the pulps on the mat at the corresponding places of the grass and hair. In order to get an exact idea of the manner in which they occur we have to consider the condition of the under surface of the wet sheets immediately in contact with the grass mat, in the process of paper-lifting, When the water drains away from the pulp on the mould the upper surface of the wet sheet is quite plain and even, but the under surface is not so plain or even. If the grass mat with the wet sheet on it, is cut across as at A B (Fig. 10) and held in eye-level it will have the appearance as shown at I (Cross section on A B, magnified).

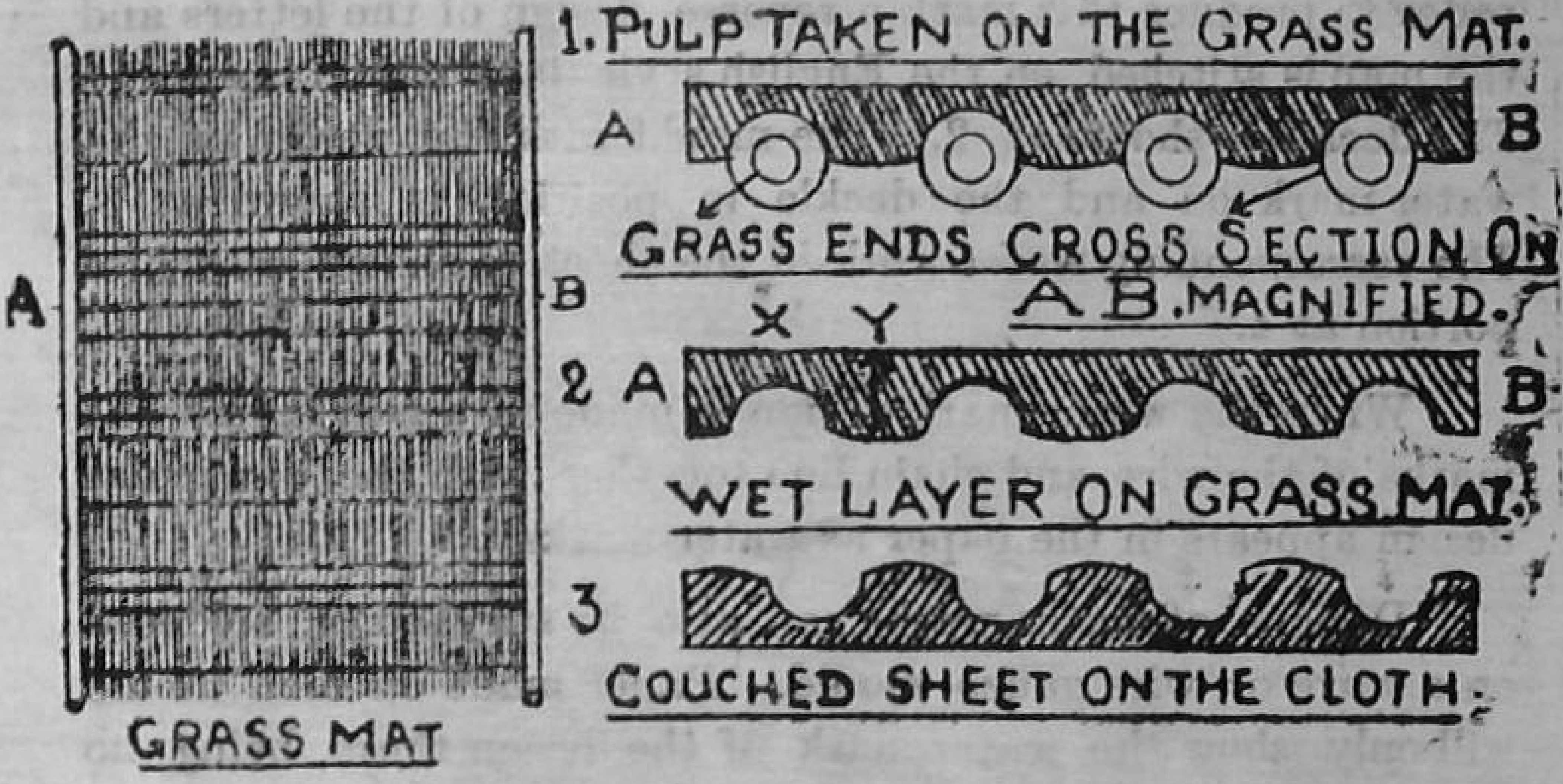


Fig. 10

The grass part is shown by concentric circles. The condition of the pulp on the mat is shown at 2. It will be noticed that the thickness of the pulp at X is lesser than that at Y. Note also that the upper line representing the upper furface of the sheet is plain. The cross section of the couched sheet is shown at 3. In couching the sheet the upper surface of the wet sheet lies on the cloth with the former under surface (which is corrugated) now lying upwards. When the sheet is pressed and dried, it shows transparent line at X. The portion at Y being thicker than at X remains opaque. It will be thus seen that the translucent or transparent water-marks are caused by the difference in the thickness of the pulps in the sheet.

Form this it will be clear that in order to produce a particular water-mark in the sheet a corresponding raised design is required to be stitched of soldered on a mould, so that the pulp at the corresponding place will be thinner appearing as water-mark in the paper. The simplest line water-mark is made by stitching a thin wire design or letters on the mould. (See Fig. 11) English type moulds either laid or wove all well suited for good water-marks.

In the illustration a water-mark "Poona Bond" with the map of India is shown by white portion in the paper (4). In

order to produce this mark a reverse design of the letters and the map is stitched on the English style laid mould as at (1). The deckle is shown at 2. The mould with the design of the water-mark on and the deckle in position is shown at 3. The corresponding water-work in the sheet is shown by white portion at 4.

When the water-mark design is made on a laid mould, the marks of the wire and chain line together with the particular design appears in the paper as water-marks.

Designs of water-marks can also be stitched or soldered on a wove or wire gauze mould. Paper made on such mould will only show the water-mark of the design there being no chain or wire lines in the sheet. However if the wires of the gauze are hard and thick and pores are big then they will appear as squares in the paper.

If a broader or thicker water-mark is required in the paper, the corresponding design is cut from a thin copper or silver plate and carefully soldered on the mould.

Light and shade water-marks are produced in the paper by pressing a corresponding design in the wire cloth by means of a die in which the design is engraved.

The water-marks have been used as distinguishing trade marks by the different manufacturers from the ancient times to this present day. They had been useful in detecting frauds or forgeries.

The different names for the different papers have their origin in the ancient water-marks, *e.g.* foolscap paper derives its name from the ancient water-mark of a cap with bells worn by fools or jokers who were common in the old aristocratic families of England. Similarly pot-paper has its origin in the pot or jug as water-mark. Post-paper derives its name from the water-mark of the postman's horn in the earlier periods of paper-making. The production of water-mark in a sheet of European origin and dates as far back as the close of the 15th century. John Tate made some water-marked paper.

COLOURED WATER-MARKS ARE PRODUCED IN THE WET SHEET AS FOLLOWS. First a thin sheet is couched on the table, then designs either in letters, flowers, leaves etc., previously cut from thin coloured paper are placed over the wet sheet. Another wet sheet without piece of cloth, is then couched over this without disturbing the arrangements of the designs. After pressing, the sheets look as one with the coloured design in it.

Auother method is, instead of cut designs from coloured paper, templates are cut in appropriate designs which serve as deckles on a small frame. They are dipped in coloured pulps as in paper-lifting and the templates are removed and the designs in the coloured pulp is couched on the wet sheet over which another sheet is couched as before and pressed.

1. LAID MOULD.

Fig. II—1

2. DECKLE.

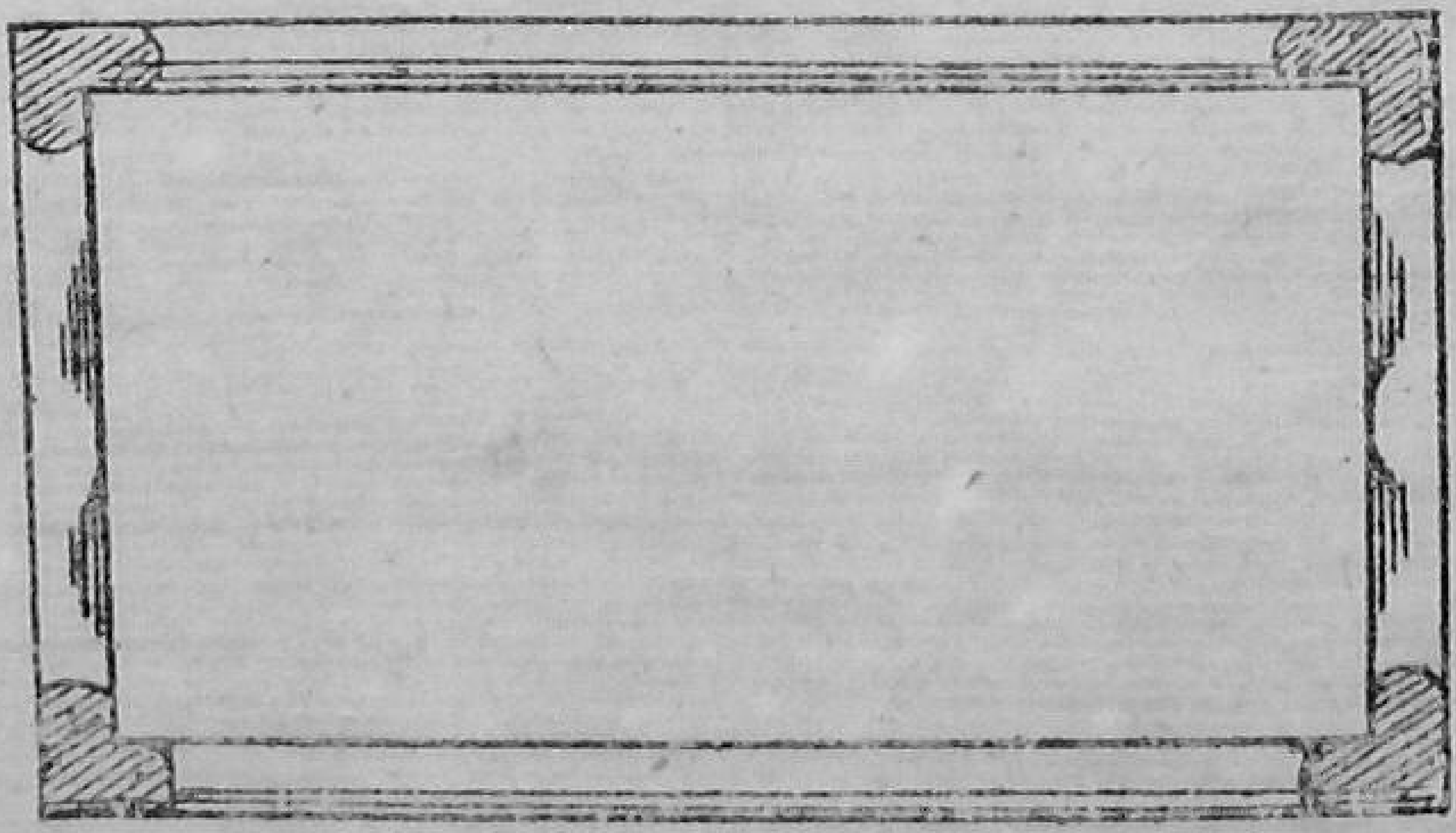


Fig. II—2

3. MOULD WITH DECKLE.

Fig. II—3

Fig. II—4

CHAPTER IX

SIZING OF PAPER

UNLESS the pulp is pre-sized, the sheet is somewhat absorbent and is termed waterleaf. Such papers as blotting and filter papers are required to be absorbent. But for writing purposes the paper should be non-absorbent *i.e.* the ink must not spread upon it, making the writing blurred, ugly looking and illegible. This is done by the process of sizing. The degree of the sizing is dependent upon the special purpose for which the paper is used. For instance paper intended for ordinary handwriting is required to be hard sized as writing inks are very fluid. Writing inks are made of a large portion of water with a small percentage of gallotannic acid (extracts of myrabolums or gall-nuts), copperas (ferrous sulphate) and colouring matter to make them bright.

The paper intended for printing is not so hard sized. Printing inks are thick and are composed of carbon or mineral pigments and thickened linseed oil. Moreover the ink after printing is required to dry within a short time. In such cases a small absorbency in the sheet is helpful.

The character of the pulp also determines the degree of the sizing in the sheet. In wet beating of pulps with the blunt knives of the beater or the teeth of the stampers, the pulp gets hydrated and the collulose is somewhat gelatinized giving proportionately a non-absorbent character to the sheet requiring less sizing; while in the case of free beaten pulp the cellulose is not so hydrated and the sheet is more or less, absorbent, hence it requires more sizing. Moreover the degree of the sizing is also dependent on the thickness or thinness of the sheets, the former requiring less and the latter more of the sizing materials.

There are four different processes of sizing:—

(i) Starch sizing; (ii) Glue or Gelatine sizing; (iii) Rosin sizing; (iv) Casein.

(1) STARCH SIZING

The starch may be made out of one of the following:— wheat, maize, potato, sago, rice, arrowroot, plantain, or sweet potato. Generally wheat or rice starch is used.

To prepare starch from wheat. Wheat is soaked in water and kept for 2 or 3 days to soften but not allwed to sprout. During this process acetic acid is generated in small quantity which dissolves the gluten from the wheat. It is then pounded wet and mixed with plenty of water and strained through a sieve to separate the milky starch fluid from the husk. It is allowed to settle for some time for the starch to sink to the bottom when the upper water is drained off. The precipitate of starch at the bottom is washed two or three times with sufficient water and the upper clear water is drained off each time. The starch should either be dried or may be directly converted into paste for immediate use.

Rice starch can be prepared by soaking the rice in water overnight, by straining of the water and washing the rice two or three times. The rice is next somewhat dried and ground into flour and washed several times as in wheat starch.

To prepare starch from other materials. The materials should either be ground or crushed to an almost pasty form (in the case of potato or plantain) and mashed in sufficient quantity of water and strained as above. The strained liquid is allowed to stand for some time when the starch settles at the bottom, and the clear water is drained off. Washing is repeated a number of times to make the starch as pure as possible.

Sizing process. The percentage of starch to be used varies from 10 to 20%. The starch is mixed with water about 12 to 15 times its weight to form a uniformly thin mixture. This is then heated slowly to a thick paste and continually stirred so as not to form lumps. When the paste is about to boil, 10% alum and 2% copper sulphate, (on the weight of the starch) both dissolved in water are added and stirred well to mix uniformly and then without further boiling the whole mixture is taken away from the fire and cooled.

Next the paper is taken sheet by sheet and the starch paste applied to it on one side by means of a soft brush or a piece of cloth or coir and the sheets dried by hanging them

on ropes. When one side is thus dried, the other side is similarly given starch paste coating and dried as before.

If the paste is very thick both the sides may be coated at the same time and hung on ropes to dry. But this is not generally advisable.

(2) GELATINE OR GLUE SIZING

Gelatine or glue is obtained from hides, horns, hoofs, fleshings, bones, etc., from the dead animals. They are soaked in water with lime for a number of days till they are swollen and softened. They are then washed thoroughly and neutralized with dilute acetic, hydrochloric or sulphuric acid. They are again washed well and extracted with water at 95 to 98° C for two to three hours. The fatty scum that floats on the top is skimmed off with a ladle and the extract is filtered through cloth and dried at room temperature. Or the solution may be used direct for sizing.

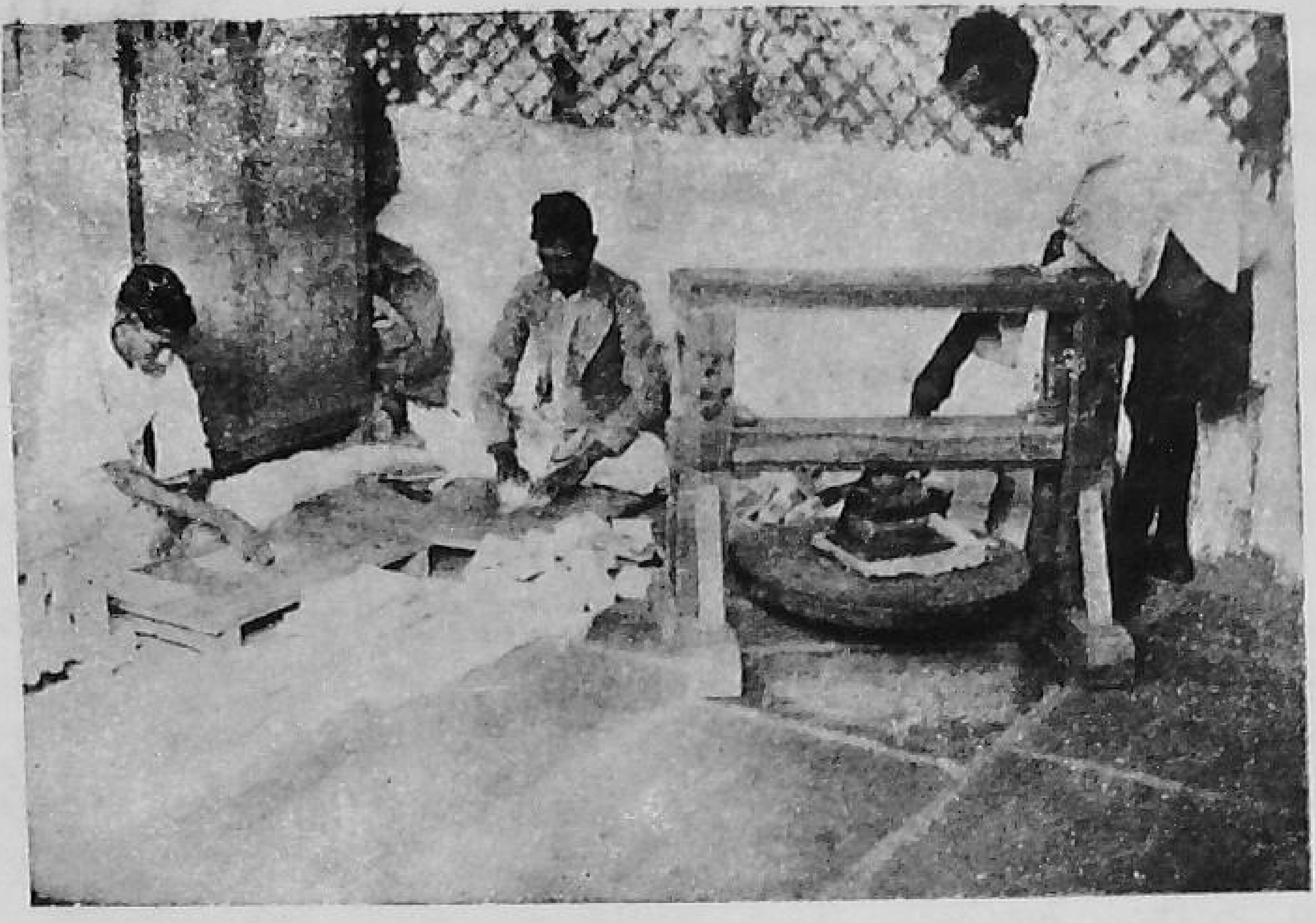
Gelatine is a purer form of glue. Glue chosen for the size should be of a light colour and must have good setting or jellifying qualities.

TO PREPARE GELATINE OR GLUE SOLUTION. Gelatine or glue is first cut into small pieces and soaked for some hours in cold water and heated over a slow fire till all of it goes into solution. It should not be boiled, as this impairs the properties of the glue. To the glue solution, alum about 12 to 15% of the weight of glue is added slowly while stirring. The alum must be previously dissolved in water. Even if the mixture thickens at the beginning, alum solution should continue to be added when at the end the mixture will again become fluid.

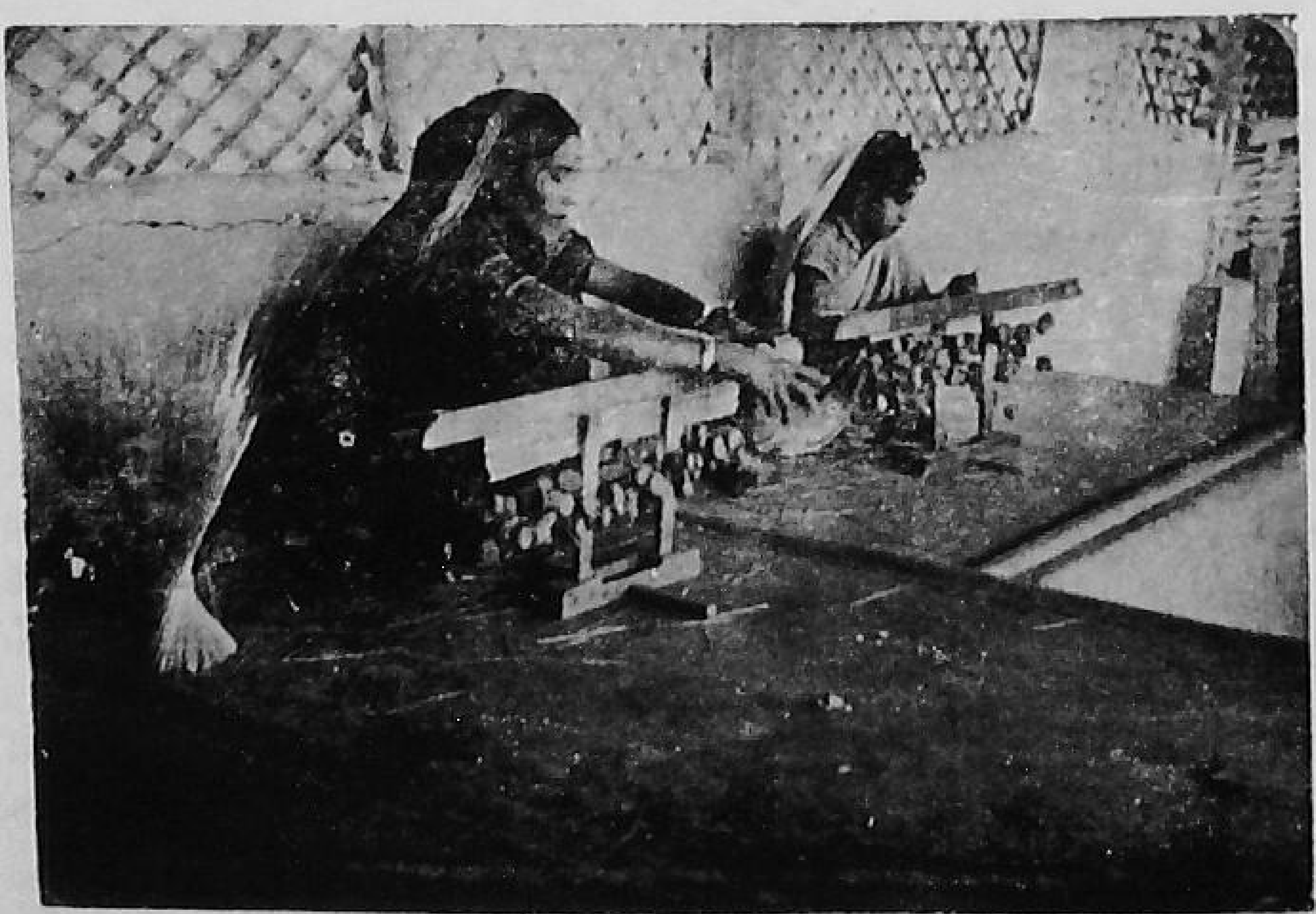
THE SIZING PROCESS. The mixture of gule of gelatine and alum should be made at 1½ to 2° Be'. It is made hot and poured into a trough of suitable size. The paper is sized by dipping it sheet by sheet in the hot solution, It is thoroughly soaked in the liquid so that it is sized uniformly all over the surface. The sizing liquid should penetrate thoroughly into the pores of the paper by expelling the air. The sheet is then piled one over the other taking care to leave no air spaces in

Starch-sizing

Tub-sizing



Cutting and Envelope making



Mat making (See page 154)

between the two sheets. A piece of cloth and then a board is placed on the sized sheets. Afterwards the pile is pressed by putting weights over the board to remove excess size from the sheets. They are then separated and hung on the rops to dry.

The glue sizing can better be done in a semi-circular or hood shaped wooden tray. Its size is 42" long and 27" broad at the top and 9" deep at the centre. In constructing this, two curved boards, almost semi-circular in shape are made. Their size is 42" long and 10" deep at the centre and 1" thick, ½" square grooves corresponding to the curvature of the boards are made into them at a distance of ½" from the bottom, Boards 10" long and 1" thick and of suitable breadth after properly shaping the inside and outside curvature are fitted into these side-boards. All the joints are made by the tongue and groove method. The joints are filled with a composition of 2 parts rosin and 1 part beeswax melted together to make them leak-proof. When all the parts are assembled together they look like a hood. This tray is convenient and economic for dipping the sheets into the glue solution. The wastage of glue solutions is reduced and there is no danger of corrosion as in metal trays.

The gelatine or glue size taken by the paper comes to 12 to 14 per cent of the weight of the original paper, After drying the paper becomes hard. In order to make the paper supple and take a good finish some softening agent such as sulphonated castor oil, good neutral soap or glycerine is added to the extent of 5 to 6 per cent of the weight of gelatine or glue. The soap added to the glue solution must be of good quality, free from adulterations and of neutral character such as is used for washing silks or wool. It should not curdle when alum is added to the gelatine solution. The soap should be dissolved in boiling water and added to the glue solution before adding alum to it. In case soap is added to the size the quantity of alum should be increased by 2 per cent.

In order to economise the use of gelatine or glue which are costly products the pulp may be partially sized with about ½ to 1 per cent of rosin size and the sheets sized with glue.

By this the glue size taken by the paper comes to about 6 to 8 per cent.

The glue sizing is known as animal or tub or vat sizing. The sheets so sized are known as T. S. (Tub sized).

The following are the Baume' degree of the solntions at 60° C of different percentages of glue or gelatine with corresponding proportion of sulphate of alumina added to them,

Glue or Gelatine Parts by weight	Alum Parts by wt.	Water Parts by wt.	Baume degrees at 60°C
100	12	1400	1°
100	12	1200	1½°
100	12	1000	2°
100	12	800	3°
100	12	600	4½°

The suitable degrees for sizing the paper are 1° to 2° Be' In case no baume' hydrometer is available then the solutions may be made in the proportions of glue of gelteine to water for the different degrees *e.g.* for a soultion of glue of 2° Be' the proportion of glue or gelatine to water should be 1 : 10, the alum being in corresponding proportion.

The Nitrogen contents of glue and gelatine are 13·9 and 14·5 respectively.

The Results of the tub sizing experiments on rag paper at different degress of Be' solutions at 60°C are as under :—

Degree Be'	*Increase in weight of paper*	*Remarks*
1° Be'	12·0%	Ink resistant
1½° Be'	14·0%	,, ,,
2° Be'	21·0%	Heavily sized

In the above experiments the paper was not heavily pressed to squeeze out more solution from the paper. However, the results indicate that when the pressing arrangement is light, glue or gelatine solutions at 1° to 1½ Be' would be most suitable while with heavy press, the solutions to be used should be at 1½° to 2° Be'.

Another experiment conducted on drawing paper from sunn-hemp showed that with 1½° Be' soultion of gelatine, the increase in weight was only 10·0% as against an increase of 14.0% on rag paper. This shows the absorbent character of rag paper. The sunn-hemp paper used in the above experiment was from well hydrated pulp, requiring less amount of size.

(3) ROSIN SIZING

Rosin is obtained as a by-product in the distillation of oleo-resin for turpentine. This oleo-resin is obtained from pine trees found in the forests of the Himalayas, Punjab, U. P., etc. Rosin is of a friable nature and varies in colour The pale coloured variety known as N quality is preferable for use in paper sizing.

Rosin size is never given to paper after it has been lifted but is added direct to the finally prepared pulp before sheet making.

To PREPARE ROSIN SOAP. Rosin soap is prepared in the proportion of 6 parts of rosin to one part of soda ash and 12 parts of water. The vessel used for boiling should have about 2 to 3 times the capacity of the water. The soda ash is first dissolved in water and placed on the fire to boil. Then the rosin previously broken to about the size of gram is added slowly in small quantities while stirring, and allowing a little time for the foam formed as a result of the combination of the rosin with soda ash to subside before any fresh addition of rosin. If this precaution is not followed then there is a possibility of the contents spilling over the brim of the vessel and thus making the subsequent operation useless.

After all the rosin is thus gradually added the mixture should be boiled for about ½ to 1 hour for the complete union of rosin and soda ash. The total time taken for the saponification of rosin is about 5 to 6 hours. From time to time some water should be added to make up any loss caused by evaporation. After all the contents are boiled as directed, the soap should be taken away from the fire and kept for some days, when a black fluid may separate which should be drained off. The rosin soap thus prepared should be converted into a

solution of known percentage of rosin, preferably to represent 10% of rosin in the solution by measure, *i.e.*, the soap should be so dissolved in water that the final solution will be ten times the quantity of rosin (and not of rosin soap).

Or in case when no stock solution (1-10) is made as stated above, the weight of the prepared soap without the container may be found out. From this the proportion of rosin soap to rosin should be calculated. The actual soap required for sizing the dry pulp may be determined accordingly and taken by weight from the stock and dissolved in sufficient quantity of water, generally 5-6 times the weight of the soap before using. For example: $7\frac{1}{2}$ lbs. of rosin were converted into soap as described earlier. The soap without the container weighed 25 lbs. Then one part of rosin is equal to $25 \div 7\frac{1}{2}$ or $3\frac{1}{3}$ parts of soap. Supposing 2 lbs. 13 ozs. of rosin are required to size the pulp as in the succeeding illustration then the soap that should be taken for sizing will be 9 lbs. 6 ozs. (2 lbs—13 ozs. $\times$ $3\frac{1}{3}$. This should be dissolved in about 4 gallons of water and used.

Note :—To dissolve the rosin soap in water, all the water should not be added at once to the soap. Only a small amount should be first added to the soap and well mixed, then gradually more water should be added to dissolve it. In this way all the water is added gradually till the whole soap goes into solution with a milky appearance. This will give a homogenous mixture. Otherwise there is likelihood that the soap may form lumps which will ultimately be difficult to dissolve.

To SIZE THE PULP WITH THE ROSIN. The whole quantity of the prepared pulp should be weighed, and from this exactly 10 tolas of the pulp weighed on a gold-smith's balance should be taken and dried in the sun, taking care that none of it is removed or any foreign material added to it by the wind. When completely dry it should be weighed in the same balance. The weight obtained represents the dry pulp from 10 tolas of the wet pulp. From this the quantity of the actual dry pulp in the total wet pulp can be calculated by the simple

rule of three. Rosin given to pulp is about 4 to 6 per cent on the actual dry contents in the wet pulp' The requisite amount of rosin soap or rosin solution (1 to 10) required for the prepared pulp having been determined, it should be mixed with sufficient quantity of water and added slowly while the pulp is being stirred either by hand or trampled under feet. The rosin soap solution must first be mixed thoroughly and uniformly with the pulp. Then the solution of alum should be added in like manner to the pulp and rosin mixture. The proportion of alum to rosin is as given below. There are two varieties of alum, one, the sulphate of alumina which requires to be 1½ times the amount of rosin (not rosin soap). The other variety is the common alum of the bazaar which is required in the proportion of 2½ parts of alum to 1 part of rosin. The alum should be dissolved in about 10 to 15 times the quantity of water before it is added to the pulp and rosin mixture.

Illustration. Suppose you have about 250 lbs. of wet pulp. On drying exactly 10 tolas out of this, you get 2.25 tolas of dry substance. It is required to give 5 per cent of rosin to the pulp. The quantity of the dry substance in 250 lbs. of the wet pulp is $250 \times \frac{225}{10} = 56.25$ lbs. Accordingly the amount of rosin required will be $56.25 \times \frac{5}{100}$ =or 2 lbs. and 13 ozs. This quantity of rosin is contained in (2 lbs.—13 ozs.) ×10=28 lbs—20 ozs. solution by measure. This calculation is made on the basis that the rosin soap solution made represents 1 lb. of rosin in 10 lbs. of water. Now measure this quantity of rosin solution and mix with it about 22 to 25 lbs. of water. Pour this solution slowly into the pulp while mixing it well. See that all the pulp is well mixed with the rosin solution. Calculate the amount of alum required. It is (2 lbs.—13 ozs.)×1½=4 lbs.—3½ ozs. of sulphate or alumina or 2 lbs.— 13 ozs.)×2½=7 lbs. ½ oz. of common alum. Powder the required quantity of the alum of either the first or the second variety, and dissolve in about 50-60 lbs. of hot water and pour slowly into the mixture of pulp and rosin, while stirring. The effect of the rosin solution and alum is to render the fibres of the pulp non-absorbent. After thorough

mixing the pulp should be put into the vat. If there is any foam after stirring it should be skimmed off. The paper lifted from rosin sized pulp, requires no other treatment than drying, polishing and cutting. It produces a smooth surface.

Starch of China clay or both may be added to the rosin sizing mixed in the proportion of about 5 per cent of starch and 7 to 10 per cent China clay, on the weight of the dry pulp. If they are to be added, they should be previously mixed in water and strained through a seive into the rosin soap solution (and never in alum solution) and added to the pulp and mixed well. Then the alum solution should be added. Use about one-half per cent more alum than the quantity required for plain rosin. Starch and China clay in the rosin sizing fill up the pores of the unized paper and give a smooth appearance when the paper is polished.

Rosin soap and alum solution should never be mixed together as they form a precipitate which will not be taken up by the pulp. So it is always necessary that the pulp should be first mixed with rosin soap solution and then the alum solution added.

In machine made paper, somewhat less rosin is used for sizing the paper. Generally it is 3-4% while in hand-made paper a higher percentage *e.g.*, 4-6% is required to size the paper. The hand-made paper sized with rosin is softer in feel than the machine-made paper. The reason seems to be that in mills, paper is dried on hot drying cylinders with the result that the rosin in the sized sheet, softens or melts which completes the process of sizing the fibres with rosin; so also on cooling the rosin solidifies as hard particles on the fibre. While in hand-made paper, rosin does not crystallize on the fibres hence the paper is soft.

It is sometimes found that even with larger proportions of rosin, the writings are blurred. In such cases it is better to apply a thin coating of starch paste or to dip the paper in a thin solution of starch in water (1 in 50). This completes the process of sizing and hardens the paper with an elastic feel on polishing. Or the rosin sized paper may be hot calendered or ironed.

(4) CASEIN SIZE

Casein is a by-product in the manufacture of butter from milk. After separating the cream, the skimmed milk is soured to from buttermilk. When this is heated, it curdles into a white substance known as casein. The water is drained away. The curdled mass is washed several times to purify it and ultimately dried at low temperatures. This is known as lactic casein. It has a yellowish white colour. The other method of coagulating casein from skimmed milk is to add dilute solution of hydrolchoric acid. The water is then separated from the coagulated mass which is washed several times to purify it.

Casein appears yellowish white or white in colour and occurs in small granules which are insoluble in water. It is dissolved by lime, caustic soda, soda-ash, silicate of soda, borax and ammonia to form a thick paste. It is precipitated from its solution by alum. As a sizing material it has no ink-resisting properties. Hence it cannot be used alone for this purpose, but along with rosin size. When added along with rosin in 3–4% on the weight of the dry pulp, it increases the elasticity and strength of the sheets and gives some of the properties of tub-size to the paper. Casein is mixed with 5 to 6% of its weight of lime or 10% borax and dissolved in 20 parts of tepid water adding it in small quantities and kneading the mass well each time to form a homogeneous paste. When used along with rosin more alum is required to precipitate the casein. After final addition the pulp must test acidic to litmus paper. Since casein solution is likely to putrefy if kept for some days it is preferable to add some preservative like salicylic acid or formaldebyde in small quantity. Casein is largely used in coated paper as a vehical for pigments.

COMPARATIVE MERITS AND DEMERITS OF THE DIFFERENT KINDS OF SIZING

(1) *Starch size.* This is easy of manipulation and easily available in villages, but it is costly both from the point of view of labour and to a certain extent of material also, as about, 20% sizing is required to be given to paper. If not properly

sized, the paper is not thorougly non-absorbent to modern fluid inks as against the old lampblack inks which are somewhat thicker. Besides it is likely that rats, silverfish, worms and other insects may eat away the paper if not properly preserved.

(2) *Gelatine or glue size.* Gelatine or glue sizing is the best and the easiest to manipulate requiring less labour than starch sizing. Owing to its gummy nature, and the penetrability of the solutions into the fibres, and the effect of the hardening of the size in the paper, this mode of sizing is the best of all the sizing methods, and is especially preferable for paper intended to last long, as it is a hard and durable sizing. Glue sized paper is also strong. It is only used for high class paper.

(3) *Rosin size.* As in the previous case this also requires less labour, as the paper after lifting and drying is directly polished without further treatment. It makes the fibres waterproof. It is useful for ordinary writing and printing paper. It is not recommended for paper intended to last long. Minerals like China clay, Gypsum, French chalk or Soapstone, Starch, etc., can be incorporated with the rosin to increase the weight and fill up the pores of the paper. Unlike the other two methods, instead of sizing the paper after it is dried, the sizing material is used with the pulp before lifting the sheets.

The first two modes of sizing are known as surface sizing and the last one is known as engine sizing.

CHAPTER X

PAPER FINISHING, POLISHING AND CUTTING

After the paper is dried and sized, it is still not in a fit condition for writing, as the surface is rough and uneven and requires to be polished and made even for smooth and easy writing. Before polishing, the sheets are cleaned by rubbing the surface with pumic stone or by rough cloth to remove the particles of wood, dust, sand, etc. The appliances required for polishing are a concave board about 3 feet long 9 inches broad and 7 inches thick with a curvature of about 4 inches, its curved surface being polished, (See Fig. 8) and a quartz or agate stone, elliptical or egg-shaped, about 5" long and 3" thick, having sufficient weight *i.e.* about 4 to 5 lbs. If the stone is small, it is tightly fixed in an earthen mould, also egg-shaped. In either cases the stone must have sufficient weight and lenght to give a firm handle or grip while using. The side of the stone, which is used on the paper for polishing, must be thoroughly smoothed or polished before putting it to use. Other devices for polishing are a conch shell, or a glass roller or a paper weight. The paper is placed on the concave board and rubbed lengthwise by means of either the stone or the conch shell, etc. Some pressure is required to be exerted. Sometimes it is advantageous to lubricate the stone with a very slight film of oil to lessen the friction and to give a smooth surface to the paper. After one side of the paper is polished the other side is also treated in the same way. Polishing requires hard labour and practice. An average strong man should be able to polish about 4 to 5 quires a day, after some practice.

Polishing or smoothing can also be done by using a dhobi's (washerman's) heavy iron. Before ironing, the paper must be slightly damped. The process followed is the same as in ironing clothes. It is sometimes advantageous to use a piece of cloth between the paper and the iron.

Calendering. In modern practice the paper is smoothened by pássing it between two heavy rolls. This is also known as plate-glazing or plating. The machine that does this work is called a calender. It consists of two cast or

chilled iron hollow or solid rolls 3' long, 8" in diameter and one inch thick. 2" shafting passes axially through each of these rolls. The rolls are mounted on a stand into brass bearings. Two gear wheels $7\frac{3}{4}$" in diameter having 40 teeth to each of them are fitted into shaftings of the roll. The pressure on the top roll can be increased by means of wheeled screws or springs over the bearings. A small camber of 1/32 of an inch is given to the top roll. Two tables 3' high and in level with the bottom roll are fixed on either side of the machine. The calender is worked by a handle attached to the bottom roll (See plate 7).

The calender described above is mostly useful for writing, blotting paper etc. For stronger papers like bond, drawing, straw boards etc., a heavy weight calender is most useful. It must be 12" in diameter and 36" in length and should preferably be made of 2" thick or solid cast iron.

The pressure on the upper roll should be exerted by means of heavy springs or lever and weight arrangements on the journals instead of pressing them by wheel screws as described above. With this arrangement the pile of paper will be evenly pressed as its thickness is not always the same in different places. In the wheel-screw arrangement, sometimes the sheets get black spots on those portions which are thick. With the other arrangement the roll adjusts itself according to the thickness at different sides of the pile. The drive is taken indirectly on the lower roll by suitable gear arrangements. The calender should make only 20 to 25 r. p. m.

Operation. For smooth finish 8 to 10 sheets of paper to be glazed are piled alternately with polished sheets of either copper or Zinc in the order—first a metal sheet then the paper, then again a metal sheet and so on the last sheet being of metal. This pile is passed between the two rolls several times backward by turning the handle of the lower roll till the desired finish is obtained.

With this sort of calendering machine it is possible to give several finishes to the paper, the most common being the "linen finish" in linen paper. For such finishes textiles of appropriate design and texture are chosen. For instance

Sheet cleaning

Sheet Glazing

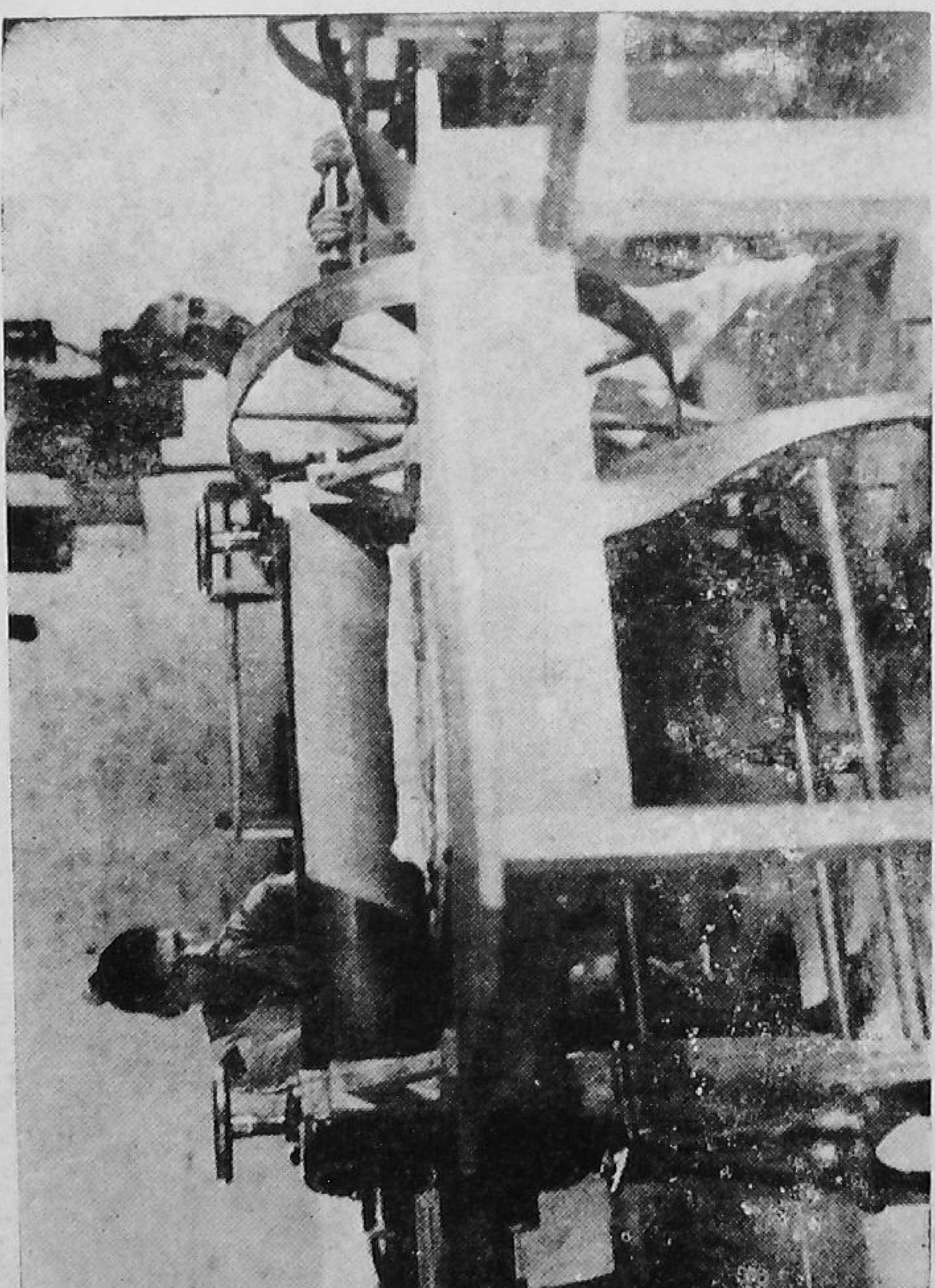


Plate 7.—Calendar

muslin or long cloth is chosen for the linen finish. In order to produce grain texture, crepe cloth is chosen.

As in the previous case the sheets of paper are piled alternately with the textile cloth instead of the metal sheets. This pile is placed between two metal sheets and passed between the rolls as before. The sheets of paper get the impression of the textile used.

After the paper is polished it has to be cut to the required size. For this purpose it is well to have wooden boards of the different sizes of paper required, with perfect edges. The sheets of paper are placed over a wooden board or a cutting table and over them a wooden board of the required size is firmly held in position to cut the borders. The cutting instrument is a knife of suitable length. This should be so manipulated that it gives a single cut to the paper. With small knives the cut edge is not perfect. After the borders are cut, the paper may again be cut into suitably smaller sizes. In Fig. 8 is illustrated a portion of the paper cutting blade (knife) B. The knife is perfectly straight. The letter A shows the side view of the blade. This knife is useful for giving the paper a single cut, but requires some arrangements to give parallel cuts similar to guillotine paper cutting machine.

Chapter XI

WHITE AND COLOURED PAPERS

Practically every kind of paper except a very few varieties, is required to be coloured with some kind of dye. Even the co-called white paper is not an exception. It will be observed that paper made from fully bleached white pulp has a yellowish tinge which is required to be toned with the addition of a very small quantity of a suitable dye to produce white effect in the paper. In everyday practice it will be observed that even the washerman dips the white clothes in a solution of laundry blue, thereby developing the white tint of the clothes.

For dyeing the paper white, the following colours are used in very small proportion.

For blue effect ultramarine, smalt, soluble blue B, methylene blue, etc. are used.

For reddish effect rhodamine B, Imperial Red or chlorazol fast scarlet are used.

For violet methyl violet may be used.

The dyes may be divided into three classes.

(1) Mineral pigments ; ultramarine blue, powdered cobalt glass (smalts) for blue ; earth colours such as mineral red (geru) ; mineral yellow (pili matti or piwadi).

(2) Vegetable dyes : turmeric for yellow ; safflower for pink ; indigo for blue, catechu for brown, madar for red.

(3) Coal-tar dyes : There is a vast number of colours prepared from coal-tar. They are cheap and easy to handle.

The coal-tar dyes used in paper-making are divided into three classes : (1) Direct or Substantive dyes, (2) Basic dyes, (3) Acid dyes.

The direct colours are readily absorbed by the pulp while the basic and acid dye stuffs require an aid in order to precipitate them on the fibre.

In the case of basic colours, substances of an acidic nature such as alum or tannic acid and in the case of acid colours basic substances such as alumina precipitated in

sizing the pulps with rosin soap and alum help in deying the pulps with the respective colour.

Generally colours of the substantive or direct class dye stuffs are preferable for dyeing the pulps. This is especially the case when the paper is not to be sized with rosin and alum. When the pulp is to be sized with rosin and alum, dyes of the basic or acid class may be used for dyeing as the acidity of the free rosin in the soap or the basic nature of the alumina generated in sizing the pulps with rosin and alum help to fix the colours on the fibres.

The acid colours are very difficult to dye on the fibres and should not be used where the pulp is not to be sized with rosin. So also they are not fast to light. In dyeing the pulps with coal-tar dyes, colours of the same class should be used for mixed shades, as colours of different classes may not only not have the desired colour effect but some-times have an adverse effect.

Dyeing directions. In dyeing the pulps with mineral pigments, the colour should be mixed with some quantity of water and strained through a sieve and mixed with the pulps before adding the size. These pigments are required to be used in large quantities. They are fast to light but have a tendency to settle at the bottom of the pulps either in the vat or in the wet sheet in which case the sheet on one side may have a deeper shade than on the other.

When mineral pigments are to be used it is preferable to use starch paste before the rosin size as it helps to retain the colour in the pulp.

The ultramarines should not be used whenever alum in large quantities is to be used in the sizing process as it has an adverse effect on certain varieties of the dye. If they are to be used they should first be tested with dilute solu-tion of alum. If the colour does not fade, then only, they may be used.

In dyeing the pulps with coal-tar dyes the proportions used should be ·2 to ·3 per cent or roughly one to two ozs. of colour for 40 lbs. of dry pulp. The beginner should add the colour solution in small quantities till the desired shade is obtained. The colour of the wet pulps is sometimes

deceptive. So in trying to match any shade or desired colour in the paper, the best plan is to dilute the coloured pulp in a bucket or small vessel and take a small sheet about 4" square on a small mould. The wet sheet should be dried with blotting paper or on the wall. On drying, the true colour will appear in the paper. Adjustments can be made by the addition of suitable quantities of dyes to produce the desired shade.

In case of mixed shades the colours should be weighed separately and mixed. The amount of the colour having been weighed should be put into a pot preferably of enamel or copper, or a wooden tub, and some small quantity of boiling or hot water should be poured on the colour breaking all the lumps and making a paste. Afterwards some more boiling or hot water should be poured to get as complete a solution of the dye as possible. Then a sufficient quantity of water should be put into the dyeing vat or pots and the dye solution strained into it and stirred well. Next the wet pulp should be introduced into the vat and the whole contents stirred well, otherwise the pulp will be coloured unevenly. In many cases the dye bath will be exhausted gradually, but if it is found that the colour is not exhausted some common salt or Glauber's salt, approximately 5 to 10 per cent on the weight of the dry pulp should be added in the dye vat. When the bath is sufficiently exhausted, the pulp may be squeezed out but not washed, and directly put into the vat for paper-lifting. If the pulp is to be sized with rosin and alum it should be done after dyeing the pulps before putting them in the paper-lifting vat. The dyeing of the pulp may be done direct in the paper-lifting vat in about half the quantity of water required to fill it. After dyeing the pulp, the vat should be filled full and the paper lifted as usual. But generally it is preferable to dye the pulp in a separate vat.

In case a hollander beater is available the dyeing is better done in it while the roll is in action. In case of rosin sizing the order should be to add starch and other filling materials if any, before the dye soultion and then add rosin soap and alum as usual, each time taking care to see that the material is mixed uniformly.

When the sheets are to be dried on the walls, some colours are adversely affected by the lime plaster. Such colours

should not be used for dyeing the pulps, or the paper should be dried in some other way. The best way is to test the colour by dissolving a small quantity of it in a small glass and adding a small quantity of lime water. If the colour fades or disappears, it should not be used when the paper is to be dried on walls. Similarly colours which are affected by alum should not be used to colour the paper.

Coal-tar dye stuffs have some letters and numbers added to their name. They are meant to denote their shade or concentrations. Thus Rhodamine B denotes that the colour has a bluish shade. Methylene blue RX denotes that the colour is of a reddish shade and is concentrated. Chlorazol fast scarlet 4 BS means that it has a blue shade and the number 4 denotes its degree.

NAMES OF SOME DYE STUFFS

Direct Colours	*Basic Colours*	*Acid Colours*
Durazol Fast Yellow GRS	Auramine OO (yellow	Metanil Yellow
Brilliant Yellow		Quinoline Yellow
Chrysophene GS		
Sun Yellow		
Chlorazol Yellow 3 GA		
Benzo Purpurin 4 B	Brilliant Saffranine GR Con	
Diamine Red 4 B	Magenta	
Congo Red	Rhodamine B	
Chlorazol Fast Scarlet BS		
Cotton Scarlet		
Chlorazol Blue 3 B	Methylene Blue RX	Soluble Blue B
Durazol Fast Blue 4 RS	Victoria Blue	
Diamine Sky Blue	Paper Blue	
Direct Green GN		
Chlorazol Green	Diamond Green	
Chlorazol Orange RS	Methyl Violet BB Extra	Acid Violet
Direct Brown Yellowish	Bismark Brown R Con	
Cotton Black Extra		
Durazol Gray N 5		Nigrosene Black

CHAPTER XII

A. MANUFACTURE OF SPECIAL VARIETIES OF PAPER

(1) BLOTTING PAPER

ABSORBENCY of blottings and similar paper is capillary phenomenon of sucking liquids into the hollow tubes of the individual fibres, so also through the walls of membranes of the cellulosic fibres. If the hollow canals and the pores in the walls are choked up, as is the case in loading and sizing the fibres or with the hydration of pulps or the incomplete removal of the incrusting and other non-cellulose matter in the chemical treatments of the raw material in obtaining cellulosic fibres, they offer no free passage to the liquids or inks through them in proportion to the hindrance used by the abve. Hence a thorough treatment is given to the material in obtaining the cellulose for absorbent papers. All the raw materials have not the same capillary phenomenon. The cotton fibres having a thin wall with wide hollow tube and the cork screw appearance leaving more air spaces between the fibres form an ideal material for blottings. Old and soft rags as well as cotton wastes are very useful for converting into good blotting paper. The rags of waste cottons should be boiled with 5 to 6 per cent caustic soda for 4 to 5 hours either in an open boiler or digested in the digestors at 25 lbs. pressure. They are then washed and may or may not be bleached. Since the pulp is to be free the stuff is beaten in the shortest possible time to avoid hydration and to retain the maximum absorbency. The pulp may be coloured with a bluish pink colour. Sometimes the treated rags are retted for 2 or 3 months, before washing and beating. This tenders the fibres. The blottings from this are softer with good absorbency.

Waste paper is also useful for conversion into blotting. For this, it should be boiled with 3 to 4 per cent of caustic soda for an hour and left in retting tanks for about a week to complete the reaction. By this, not only the sizing materials are removed completely but the fibres become

tender. Then the pulp is made as usual and coloured if necessary. Congo red or Imperial red with bluish shade is mostly used for pink blotters.

The quality required in a good blotting paper is that it must have good absorbency. It must quickly absorb ink blots and writings without any blurring on the paper and without any undue pressure. For this the paper must be soft and of a smooth surface. It is not required to be strong hence it need not be well felted. The paper is not sized and hard glazed. The usual size of the paper is demi 17½" × 22½" and the weight of the ream of 480 sheets is about 40 lbs.

(2) FILTER PAPER

This class of paper is required in chemical laboratories for filtering precipitates etc. Such papers are also used for filtering juices, medicines, etc. to make them clear and free from sediments. Like blotting paper it is required to be absorbent. The paper is manufactured in several grades according to special requirements. Unlike blotting paper filter paper has to be somewhat strong, to withstand the pressure of liquids. For this new soft cotton rags and preferred. They are boiled or digested with 5% caustic soda and partially washed and kept in a heap for 2-3 months to ferment. This has softening effect on the fibres. Afterwards they are bleached with 5 to 7% bleaching powder. The pulp is made in a much shorter time than for bond or drawing paper. The paper is made as usual. It must not have any pin- holes to allow any precipitates or particles to pass through, water used for washing and sheet formation should be quite soft like rain water. So also after bleaching, some dilute hydrochloric acid should be added immediately before washing. This will minimize the ash contents in the paper.

The following results of the p. c. of ash in raw cotton, cotton cellulose and filter paper and filter paper pulps, treated differently will be found useful in the manufacture of filter paper.

	Ash Contents	Remarks
1. Raw cotton	1·21%	
2. Cotton cellulose	0·41%	Washed with tap water.
3. Filter paper from rags	0·43%	" " " " and dried on the walls.
4. " " pulps	0·31%	Washed finally with distilled water.
5. " " "	0·17%	Treated with 0·1% HCl washed with tap water.
6. " " "	0·14%	Treated with 0.1% HCl and finally washed with distilled water.

From the above experiments it will be observed that for filter paper, soft water, approaching rain water or distilled water is essential for washing the pulps in the last stage. The ash in the pulps treated in 0.10% hydrochloric acid and washed with distilled water was reduced to 1/3 of the cotton cellulose or filter paper made with tap water. For ashless papers the pulps are treated with very dilute solutions of hydrochloric and hydrofluoric acid in a wooden cask. For washing and paper-lifting distilled water must be used. The paper must not be dried on the wall as it would absorb lime.

(3) Deckle-edge stationery

Deckle-edge stationery is a special kind of hand-made stationery having artistically perfect rough edges. Such kind of paper is not cut by any cutting device. Hence great skill and care are exercised in making the deckle true to the laid or woven wire cloth on the frame so that pulps may not pass through the edges of the deckle frame making the edges of the sheet quite irregular in appearance. In order to make small note papers and matching envelopes two corresponding frames are made with partitions in their respective deckle frames, in such a way that when the pulp is taken on the frame they form separate sheets of note papers or envelopes of the desired size.

Construction of the frame and deckle. In Fig. 12 A is a frame covered with woven or laid wire gauze. B is a deckle frame. The wooden ribs G and G' of $\frac{1}{2}$" square in thickness are fixed into the frame B in such a way that they rest perfectly over the wire gauze of the frame A and make six compartments of the size of the note paper as is seen at C. In order that the pulps may not pass through G and G1' a spring S is fixed at a and a' over the rib G. Threaded key screws passing through this spring rest upon the wooden batten G at X. These screws and the spring help to keep the ribs tight over the frame by turning the threads, to prevent the leakage of the pulp through them. The couching, pressing and drying is done as usual. Generally such stationery is partly sized with rosin and partly with glue.

Deckle-edge stationery can also be made by fixing thin square wires on the mould, so as to form compartments of the size of the note papers or envelopes in the same manner as described before. The paper after drying is torn along the wire lines producing 2, 4 or 6 note papers or envelopes. Note papers must exactly fit into the envelopes. The sizes of the deckle-edge note papers and envelopes are :—

Size of note paper.	Corresponding size of envelope.
8" × 10"	$7\frac{1}{4}$" × $7\frac{1}{4}$"
7" × 9"	$6\frac{1}{2}$" × $6\frac{1}{2}$"

(4) BOND AND LEDGER PAPER

This paper is mostly used for documentary and legal purposes and account books. Bleached rag-stock from cloth made out of hand-spun yarn is preferable to gray one, for conversion into paper. The boiling and bleaching is done as usual. The rags are beaten for 10 to 12 hours with blunt knives of the beater. Each pound of pulp requires about one unit of electric energy. The hand-spun stock lends itself well for such treatment, as thereby the pulps are well hydrated. The pulps may also be made under the dhenki. In the case of ledger paper the pulps are slightly coloured with finely powdered cobalt glass or coaltar blue colour. The colour of the paper should be sky blue or somewhat paler but not deeper.

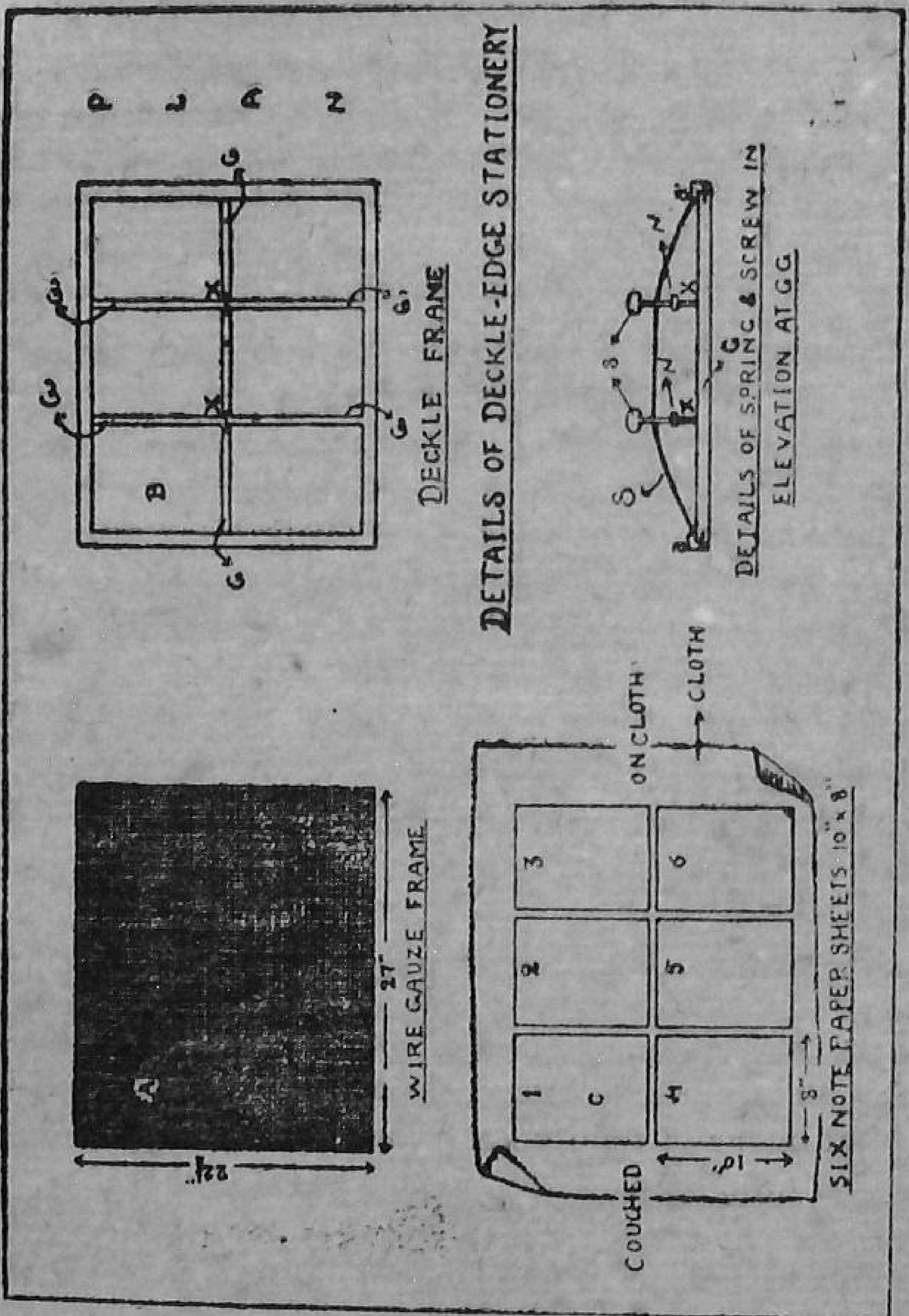


Fig. 12.—Construction of Deckle edge Stationery frame

The paper is made in different sizes. It is sized only with glue or gelatine. For cheaper varieties the pulp may be partially sized with rosin (about 1½ to 2%) and afterwards the sheets may be sized with glue. This reduces the quantity of glue required for the paper. The paper is never loaded with any loading material. The average weight of a double fools-cap size sheet is about 1 to 1¼ ozs. The fibres in these sheets must receive good and skilful felting as the paper is required to be durable.

(5) DRAWING PAPER

Drawing paper is made more or less like bond or ledger paper. Besides cotton rags, flax or linseed fibre and sunn-hemp are also useful materials. High grade artist paper is only prepared with well beaten pulps. The fibre in the pulp must be somewhat longer so that the sheet will withstand the stretch on the artist's board when wetted with sponge. The sheets must be hard sized with glue as otherwise the artist's colour washes will dry quickly which is a disadvantage as the artist's colour wash should remain wet for a longer time while working with brush. The surface of the sheet must be rough with regular grains or teeth in it. For this, the English style wove moulds are preferable, felt clothes of appropriate texture being used for couching the sheets. The sheets are pressed against one another in a powerful screw press. Cheaper varieties are made with waste paper and rags, rosin sized or partially rosin and tub sized.

The usual size is imperial 22" × 30". Each ream weighs 75 to 100 lbs. Each sheet weighs about 2½ — 3½ ozs. It is better to make the paper on a wire gauze mould.

(6) STATIONERY PAPER (WHITE AND COLOURED)

This is made out of waste paper. For better grades, rags are mixed in the proportion of 25% on the waste paper stock. The pulps are made as usual for white paper. They may be bleached with 3 to 5% bleaching powder and toned white with blue or other dyes in minute quantities.

For coloured stationery the pulps are not bleached but they are dyed with different colours to produce the desired

shades. The paper must not be dyed deep. About 2 to 4 ozs. of colour are usually sufficient for 100 lbs. of dry pulps. Mixed shades are more pleasing than simple ones. The pulps are loaded with 5% clays and sized with 5 to 6% rosin and appropriate quantity of alum. If required the sheets may be coated with a thin layer of starch or may be dipped in a very thin solution of it (1 in 50 of water). Sheets can be made in various sizes and thicknesses. The usual weight is about $\frac{3}{4}$ to 1 tola per square foot.

The paper is either plate glazed in a calender or hand-glazed on a burnisher. In plate glazing, various finishes can be produced on the paper with pieces of cloth of appropriate texture and design. For high grade stationery such finishes are preferable to smooth surface.

(7) BOOK-PRINTING PAPER

This is made more or less in the same manner as stationery paper except that the paper is not coloured unless specially required. The paper must be somewhat absorbent as the printing ink must dry quickly after printing. For this the pulps are sized with 3-4% rosin and usual quantity of alum. In order that the paper should get clean impressions of the type, it is loaded with 10 to 15% china clay. This fills up the pores in the paper and gives a smooth finish to the paper. Besides it also helps in drying the ink.

The paper may or may not be coated with starch paste as in stationery paper. It is either plate or hand glazed to produce smooth surface. The paper may be somewhat absorbent for writing with ordinary inks.

(8) WRAPPING PAPER

Wrappers are manufactured from pulps obtained from such materials as gunny wastes, manila ropes, plantain fibre, sugarcane bagasse and trash, bul-rush, linseed fibre etc. They are treated with partial amounts of caustic soda varying from 5-10% either in an open boiler or in a digestor at 25 lbs. pressure for 4-6 hours. The pulps are not bleached. They are produced by beating the materials under the dhenki or blunt knives of the beater roll for a longer time so as to bruise and hydrate the fibres well as the paper is required to

be strong. The fibres in the pulp are long. It may be sized with 3-4% rosin but is never loaded with china clay or any other materials. The pulps may or may not be coloured. The sheets may be made in any size. They are either hand glazed or plate glazed.

(9) FILE AND CARDBOARDS

These are manufactured out of waste paper. For a superior variety, rags are used in the proportion of 30-40% of the weight of the waste paper. In the case of white cards, the pulps are fully bleached and toned white by the addition of a small dye. For file boards the pulps are dyed in different shades and sized with 4% rosin and 6% alum and loaded with 10% or even more, china clay or French chalk. The sheets are .016" to 0.020" in thickness. The usual size is large imperial 23" × 32" or half imperial 23" × 16" or small half imperial 22½" × 15". Each imperial size sheet weighs 4 to 5 ozs. while others weigh 2 to 2½ ozs. to each sheet. The paper may be coated with starch paste and plate glazed in a calender or hand glazed on a burnisher to produce high glazed surface as in the case of cards. File boards must not be weak or brittle as they have to undergo considerable handling.

(10) MOTTLED PAPER

The mottling effect is generally produced in the coloured paper (mostly gray, blue or red.) by incorporating long fibred stock, coloured somewhat deeply, into the pulps which are dyed lighter with the same colour as is used for the longer fibres. Or after the pulp is prepared, long fibred stock which has a greater affinity for the dyes is mixed with the pulp. When the dye is added to such pulps, the longer fibred stock with greater affinity for the colour, dyes deeper than the rest of the pulp. Generally jute or wool is used for the mottling effect. Jute is partially treated with alkali and bleaching powder and beaten lightly under the dhenki to get suitably long fibres before it is added to the pulp. When wool is used no chemical treatment is given to it. The paper is made as usual.

(11) MARBLE PAPER

The marbling effect on the paper is produced by coating it in artistic designs with coloured pastes, which are made by mixing suitable colours with thick starch pastes. The pastes are applied to the sheets to produce the artistic designs either with soft brush or by a small piece of cloth. The designs are also made on the coated paper with bamboo or wood splinters. In order to duplicate the marble, another sheet is pressed against the first marble paper while the pastes are wet and immediately separated from it. The paper is dried on the rope and hand glazed on the board as usual, to produce glossy surface.

(12) STRAW BOARDS

Straw board is made either from grasses or grain straws such as rice or wheat; so also from bagasse, sugarcane tops, trash, bul-rush etc. The aim in the production of the pulps for boards is not to get pure cellulose but just to make the material somewhat soft. Hence caustic soda used is not in full amounts required for treating the material for ordinary paper. The material is boiled with only 5 to 8 per cent caustic soda or 15-20 per cent lime for about 3 to 4 hours in open boilers or digestors at 25 to 50 lbs. pressure. This also gives a greater yield of pulp than that for paper-making. The pulps are not bleached and may or may not be sized and coloured. The concentration of the pulp in the vat is 3 to 4% and depends upon the thickness of the board required. The average yield of the boards from these materials is from 40-60 per cent.

In pulp making the material is beaten fairly rapidly. Pulp for straw boards can also be made in a country chunam mill as is used for making chunam paste for plastering.

In making the sheets, the pulp taken on the mould is thicker than for the other varieties of paper. Sometimes two or three layers of wet sheets are placed one over the other in order to get a thick sheet. Instead of ordinary cloth hessian or jute cloth is used for couching the wet sheets of the boards. They must be pressed hard in order to make them stiff and strong.

Some times the pulps are loaded with coloured ochre (generally yellow ochre) to increase weight and give a smooth surface to the boards. For waterproof boards the pulp is sized with 2 to 3% of rosin. The wet boards are dried in the fields. The boards are not allowed to dry hard but in a slightly damp state they are piled in a heap so that they may not warp. They are calendered in a heavy calender. Boards can never be properly hand glazed as they are too thick. If the boards are hard dried and bent or warped, they should be damped with water and piled in a heap and pressed with stones or in a screw press to make them flat before calendering.

Materials treated with caustic soda produce stiffer boards than when lime is used for their treatment. The yield of the boards depends upon the amount of the alkalis used in the treatment. The following data for board pulps from sugarcane trash will be useful

Sugarcane trash	50 lbs.
Caustic soda	$2\frac{1}{2}$ lbs.
Fuel for boiling for 3 hours	$\frac{1}{2}$ Bengali maund
Power required for pulp making in 2 hours.	4 unit K. Ws.

The pulp obtained was 24 lbs. or 48%. As the quantities were small no labour data have been given. The usual size of the boards is 25" × 32" with varying thickness. Each sheet weighs from 8 ozs. to $1\frac{1}{2}$ to 2 lbs. according to the thickness.

(13) MOUNT BOARDS

Mount Boards are prepared from waste paper or waste paper and 30% rags or from coloured rags or any other materials but preferably bagasse or sugarcane tops with trash mentioned under straw boards. The materials are fully digested unlike for the straw boards. They are not bleached. The pulps are made as for writing or stationery paper without much hydration. The pulp is sized with 3-4% rosin and 5 to 10% loading materials. It may be coloured as required. The board is made in 3 or 4 thin layers. Sometimes the last layer is a coloured one the rest being gray. The wet sheets so made are hard pressed, dried and calendered as in straw

boards. The mount boards must be harder, stiffer and denser in appearance than the straw boards as it must not warp or bend during use. The surface is either plain or toothed..

(14) PAPIER-MACHÉ ARTICLES

Fancy articles such as moulded pictures or designs or trays, boxes, unbreakable containers etc., can be made from the waste pulps mixed with gums, glue or starch paste as a binder and shaping them in moulds cast in cement. The pulp thinned with water is first sprinkled into the mould to fill up the crevices and corners, then filling it with the thick paste of the pulp. This is afterwards pressed with absorbent cloth to squeeze out as much water as is possible, the irregularities again being made up by applying more paste and pressing with absorbent cloth to remove water and make it as much dry as possible to prevent shrinkage of the moulded article after drying. In order to have a smooth surface and weight, the pulp may be mixed with china clay. The articles may be lacquered in artistic designs or may be painted with oil or water colours or while moulding, the pulps in different colours may be used in an artistic way to produce attractive coloured designs.

Another way of shaping the articles is to gum the sheets, the number of which is determined by the desired thickness in the article. The pasted sheets are afterwards moistened with water and while in semi-wet condition they are pressed between a positive and negative die of the required pattern. The dies may be carved outof wood.

Unbreakable baskets may be made by moulding pastes of pulp with hand on an inverted earthen pot.

(15) DEFECTS IN THE PAPER AND THEIR REMEDIES

Irregularity in the thickness in the same sheet is caused by the mould not being in level when the wet pulp containing water is taken on it. Water tries to seek its own level and so, if the mould is tilted in one corner or one side, the water with the pulp will have a greater depth on those parts of the mould which are low. At the other sides the pulp will be less. When such sheet is dried, the difference in the thickness in

the same sheet will be apparent. Sometimes when the pulp is taken on the mould and if it is not shaken quickly, the water passes away before the pulps could be properly levelled. Levelling the pulps to uniforn thickness requires considerable practice and keen observation of the sheet after removing the deckle or in couching. The side which is thinner is required to be lowered when the mould is being shaken. The thicker side shows that the mould should be raised up at that portion to make the layer of uniform thickness. This will be noticeable especially when blotting, filter or absorbent papers are being made as the water drains away quickly from the pulps. In such cases the pulp in the vat should be stirred so as to be more uniform in the portion which is subsequently to be taken on the mould; so also the mould must be shaken without wasting any time, before the water drains away.

Transparent ugly marks. These are sometimes caused by the drops of water from the fingers falling on the wet sheet while removing the deckle or placing the cloth on it. For this, the fingers should be shaken away from the sheet to drop down water which is carried with them while lifting the sheet. Sometimes during couching the sheets, air bubbles are entrapped in the couched sheets and while pressing the wet sheets to remove water the air bubbles try to find their way out causing some of the pulp to recede from those portions. This causes watermark-like specks in the paper. To obviate this, more care should be taken to see that all the air is removed while that sheet is being couched from one side of the mould. Sometimes wavy water lines are produced in the sheet on the edges. These are caused either from the cloth not being sufficiently stretched to remove the creases or the air pockets from it or from the irregularity in couching the sheets one over the other. The sheets must be so couched as their edges will lie exactly one over the other from all sides.

Paper of even thickness couched carefully, will have no subsequent troubles.

Cockling. This is especially experienced in paper made from highly hydrated pulps during the dry climate, especially in the summer. This is due to unequal shrinkage in paper while drying rapidly. In such cases it is better to dry the paper at

night time or in a place surrounded by khus curtains, on which water is sprinkled from time to time. This prevents rapid drying of the paper with unequal shrinkage. Where this is not possible it is better to make the paper in the monsoons or in the cold weather. Generally March, April and May are not favourable months for such paper. It is the experience that such paper becomes plain without cockling in a few days no sooner the monsoon sets in. This cockling is lesser in places like Bombay where the humidity is higher and temperatures are lower than the up-country places. Generally 60 to 70% humidity is favourable for paper drying. It is also preferable to keep the sheets pressed after removing them before they are hard dried. This flattens the paper.

Paper requires certain amount of natural moisture (7 to 8%) in order to have the proper feel, finish and strength in it. In making the sheets in the hot months with dry weather the moisture in the paper is likely to be less sometimes as much as 3 to 5% or even low. Such sheets should be stored in a cool moist place till the monsoons to get matured before they are sold.

This difficulty is not mostly experienced with softer papers such as ordinary writings, blottings etc.

Holes, Specks etc. in the paper. Holes in the paper are caused by sand or foreign hard particles which sometimes fall away after drying or cleaning. Specks in paper are caused by foreign particles of dust or by unreduced materials or from pulps which have not been well stirred in the vat to separate the fibres. Hence due precaution must be taken to eliminate foreign particles at the commencement of processing the raw material, the pulps should also be carefully made so as not to leave any unreduced portion in them.

The wet sheets on the wall sometimes get torn while removing the clothes. This is caused by the long threads from the cloth finding their way into the sheets. All loose, long threads from the couching clothes should be removed and if too troublesome then the borders should be sewn. Similarly clothes should not be removed from the sheets while they are too wet. While detaching the clothes from the paper on the wall, the separation should begin from one of the upper cor-

ners and continued by carefully detaching the portion of the cloth from the upper edge and then with light hand the whole piece should be removed quickly. If it is found that the sheet is likely to tear then the cloth should be re-pressed against the paper and the separation may be tried from the vertical side. Separation of cloth from sheets requires some practice and careful attention.

Deterioration in the sheet is caused by excessive alkaline and bleaching treatment or insufficient washing, thereby weakening the pulps. Pulps are also sometimes spoilt by undue haste in treating them in the beaters or by storing them for a long time in wet condition by which they are decayed or putrified. Paper made from such pulps becomes weak.

Warping. This is prevented by keeping the paper in process or the finished paper in heaps or pressed with heavy weights for a month or two by which time the sheets are conditioned or cured and become flat. The unfinished paper is polished or calendered afterwards.

CHAPTER XIII

MAT MAKING FOR PAPER

Appliances. A wooden frame, horse hair or silk thread, knotless grass stalks or thin bamboo wires, beads of clay or glass or lead and a needle.

The wooden frame. I in Fig. 13 shows the general construction of the frame. A A1 is a wooden patti or bar about 3½ feet long, 2½ inches broad and ½ inch thick. It is somewhat rounded at the upper side in which thin slits or notches about 1/16 or 1/8 of an inch deep are made at a regular distance of ½ inch. The slits should be just broad enough for the hair or silk thread to pass easily into them. They should never be broader.

This patti is fixed into two vertical supports B and B1 which in their turn are firmly inserted into the two wooden blocks D and D1 which are about 5 inches long, 3 inches broad and 3 inches thick and are shaped as shown in the drawing. The two upright pattis or bars B and B1 are about 1½ feet high, 2 inches broad and one half inch thick. They are inserted about 1 to 1½ inches into the blocks D and D1, and into the horizontal patti A and A1 at a distance of about 6 inches from its ends. The blocks D and D1 are joined together by a horizontal piece of wood E about 1½ inches broad, 1 inch thick and of sufficient length. To this piece of wood E is fixed another wooden patti F 10 inches long, 1/2 inch broad and 1 inch thick so as to form a cross as is seen in the drawing. This cross helps to keep the frame firm and upright. Pockets may be made in this cross to keep needles, beads, etc.

Construction of the mat. To make a mat 2 or 3 strands of horse hair are taken and twisted together to form a string. Two such strings are joined together to form a sufficiently long thread. The ends of these pieces of thread are tied to the clay or glass beads of sufficient weight to keep them sufficiently tight or stretched. The pieces of thread are then placed in the slits of the upper patti or wooden bar A A1, the bead weighted ends hanging on the two sides. The threads should never be too long, but must be such that when put in the slit they remain suspended by means of the bead weights.

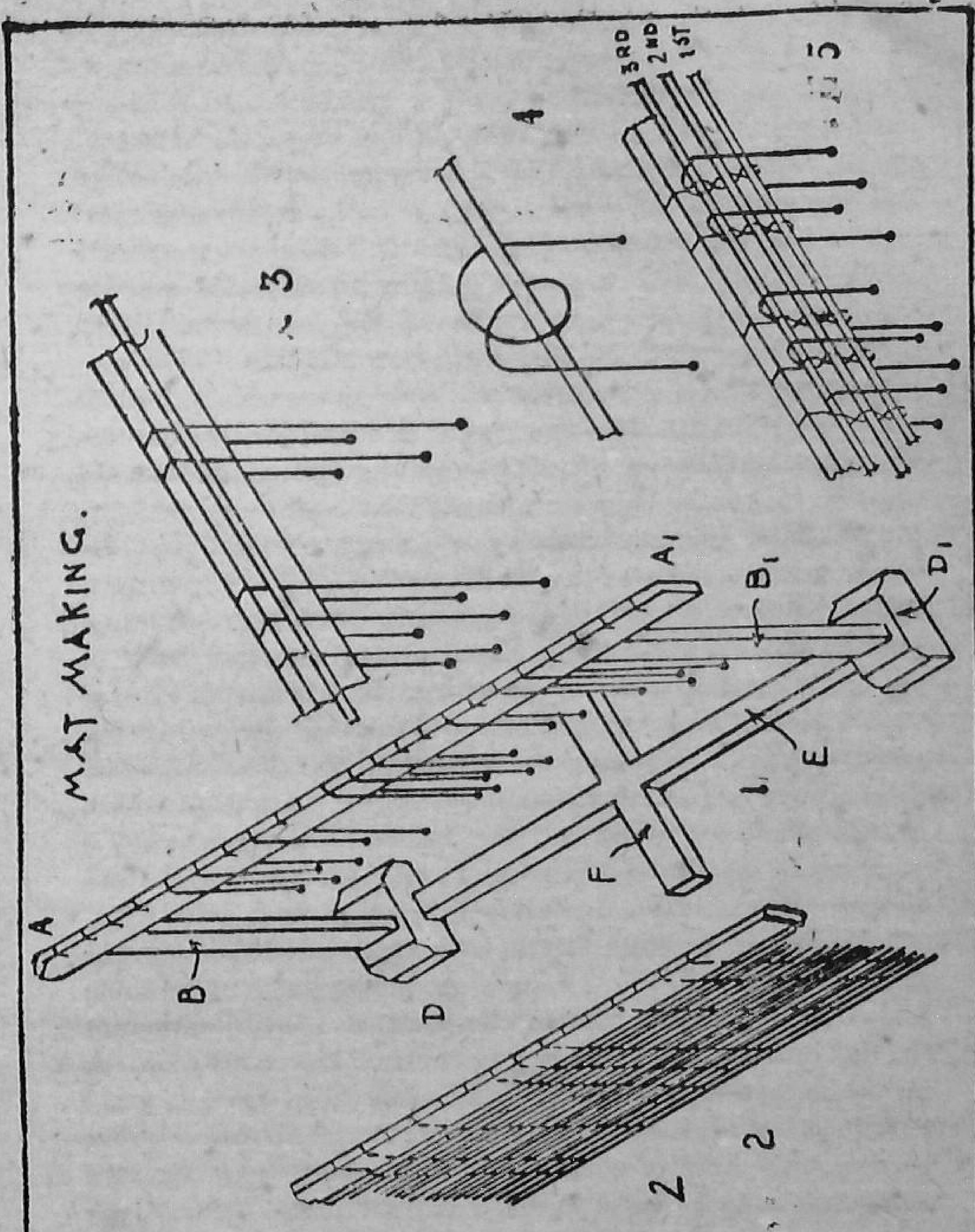


Fig. 13

The different thread are arranged in the slits according to the design of the weaving effect desired in the finished mat.

Now the knotless grass stalk or bamboo wire thin and uniform in thickness, is placed just close to the slits over the hair strings. The positions of the grass stalk, hair strings and the slits in the wooden patti or bar or better illustrated at 3 in Fig. 13. The grass stalk is firmly held under the thumb of the left hand, and the palm of the hand placed over the wooden bar A AI and the portion of the hair string on the opposite side raised by the rest of the fingers. The front part of the string is then turned over the grass stalk to the other side with the right hand and the corresponding portion of string hanging on the fingers of the left hand from the opposite side is brought over to the front side. In this way the grass stalk gets bound with a knot of the hair (See magnified illustration of the binding effect at 4). The weights suspended from the string ends keep the knots tight over the grass stalk. After this knot is made the hair string rests in the slit and not over it. In other words when the positions of the ends of the suspended strings are interchanged, they produce at their respective positi ons in the slits a binding effect on the grass stalk or bamboo wire.

This is done to all the hair strings in their respective positions in the slits so that the grass stalk gets bound over all along its length by the different strings.

If the grass stalk, or bamboo wire is shorter than the desired breadth of the mat, another grass stalk of suitable length is placed along the wooden patti as a continuation of the first stalk and the process of weaving proceeded with, as for the first stalk. When the first line is made, another stalk of a different length from the first one is placed close to the wooden patti A AI over the first grass stalk, and the hair strings are turned over it as described. Another grass stalk of suitable length placed as a continuation of this and woven as before. In this way the mat is woven to the required length and breadth.

The effect of the progress of the mat are illustrated at 5 while it is being woven. Note how the three grass stalks are woven one after the other. The binding effect of the grass

stalks by the hair strings in their respective positions is shown by the manigfied drawing in the illustration.

In case the grass stalks are shorter than the desired breadth of the mat, and two or three pieces of stalks are required to produce a single line breadthwise then the grass stalks chosen in the subsequent operations of weaving should be of unequal lengths. If the succeeding lines are woven with stalks all of equal length then instead of one mat ultimately two or three mats of shorter lengths would be produced. As an illustration suppose the mat has to be of 18 inches breadth and the grass stalks are about 7 inches long. Then for the first line if three grass stalks of 7 inches + 6 inches + 5 inches, or 7 inches + 7 inches + 4 inches length = 18 inches are taken, then the second line should be constructed with stalks of 6 inches + 5 inches + 7 inches, or 5 inches + 7 inches + 6 inches, or 4 inches + 7 inches + 7 inches = 18 inches. But on no account should the order of any line, say 7 inches + 6 inches + 5 inches or 7 inches + 7 inches + 4 inches, be continuously repeated in the next succeeding lines, as in that case instead of one mat of 18 inches breadth, 3 mats of 7 inches, 6 inches and 5 inches, or 7 inches, 7 inches and 4 inches breadths will ultimately be obtained.

Wherever more than one piece of grass stalk has to be used to form a single line, the joints should lie between two hair-lines close to each other. This will give strength to the stalks and ultimately to the mat.

Another better plan is to join the grass stalks by inserting small bamboo pins in the hollow ends of the stalks so as to form a continuous of line the desired length.

When more hair strings are required to be joined to the first strings, then the beads from the ends of the first strings should be removed and two other strings should be tied to the ends of the first strings and the two beads attached to the ends of each of the two new strings.

All the knots in the strings with their loose ends should be brought to one side of the mat with a needle, as the other side to be used for paper lifting must be free from knots and the free ends of hair as otherwise the wet sheet will be torn.

The weaving effect. The weaving effect or the chain lines produced by the hair strings will depend upon the arrangement of the strings in the different slits. This will be clearly understood from 1 and 2. in Fig. 13. In 1 is shown the arrangement of the strings at different intervals, while 2 illustrates the consequent weaving effect of these strings.

It should be noted from the drawings that the beads tied to the different strings are not in the same line, but are placed irregularly of facilitate the turning over of the string without hitch or intermingling.

The terms "length" and "breadth" used in this section should be taken figuratively and not strictly according to their usual meaning, as sometimes the breadth of the mat along the grass stalk line may be greater than the length of the mat produced by subsequent grass stalks, along the hair lines.

The hair string should generally be arranged for the most part at a distance of 1 to 1½ inches from each other. At the edges of the mat and at some regular intervals they should be arranged at a distance of about ½ inch. Particular attention should be paid to the joints of the grass stalks, where there should be a double or treble line of strings at a distance of ½ inch apart, to give strength to the mats. The mat may be woven even with silk thread.

"Chiks" or screens are also woven on the same principle by using a bigger frame either of wood or bamboo. Instead of slits small nails are fixed at regular intervals and instead of hair strings cotton yarn or thread is used.

In making the mat for paper-making its size is first determined as described under "Indigenous system of paper-lifting" (Chapter VIII page 99.) The hair lines are so arranged that the first and the last line is at a distance of ½" from the ends of the mat. A sheet made on the grass-mat shows stalk and hair line marks in the paper if it is looked through against light.

CHAPTER XIV

GENERAL CONSIDERATIONS

Factory site, water, etc. Paper manufacture requires plenty of water, about 40 to 50 gallons for each pound of paper produced. In choosing a site for starting a factory this must not be lost sight of. There must be an everlasting supply of water, since it is so important a factor. It must be clean, soft and free from suspended impurities. Generally the site chosen must be by the side of a river or tank. If these are not available then the supply should be froma well, to raise water from which arrangements should be made either for a Persian wheel or a pump.

Water is divided into two classes—soft and hard. Rain and spring water flowing through rocks is practically soft water as it contains very little dissolved matter. Hardness in water is caused by soluble salts, as while flowing through the earth or clays it dissolves not only the soluble salts, but also lime and magnesia which are rendered soluble by the excess of carbonic acid generated from the decay of vegetation or organic matter. One test to distinguish between hard and soft water is to add some pure soap solution to a bucketful of water and stir it. If the water is soft it lathers freely with practially little curd formation, while with hard water the curds formed are perceptibly in large amount before it gives any lather. Soft water is preferable to hard one for paper making as the raw material and the pulp have to go through it several times by way of washing, boiling, etc. Since lime is absorbed by cellulose, marking it brittle, water containing lime and magnesium salts are injurious for the production of good paper. In case the water is not clear or is hard it is advantageous to filter it through sand filters or soften it with lime and allow it to settle before using.

Equally important is the factor of the outlet of the used water. It should not be allowed to accumulate or soak in the ground near the factory nor to drain into its original source. A system of drainage should be provided for the factory and water carried away from the site. Such water can be profita-

bly used for the cultivation of colocasia antiquorum (अळू or पात्रा), plantain, papaya etc.

The site chosen for the factory should be away from habitations, by reason firstly of the inconvenience caused to the town or village by the drain water especially when no drainage is provided, and secondly of the noise of the dhenkis, etc. Another factor to be borne in mind is the freedom of the factory premises from dust, dirt, mud, etc. If such dirt gets mixed with the pulp or water it appears in the paper, making itunsightly or of a dull colour.

Economics of production. The aim of any industry is no only to prepare goods but also to produce them economically. The factors that count in an industry are :—(1) Availability of the suitable raw material, (2) Labour, (3) Efficiency in production, (4) Quality of the goods produced, (5) Distribution or market for the product, (6) Transport.

Provided they are suitable, the materials that go to waste should generally be used for converting into paper as their price is negligible. A few of such wastes are old clothes, spinning waste, cotton waste, tailor's waste, old ropes and fishing nets, old gunny bags, used baskets, mats and such other materials which have no other important and better industrial or other use, *e.g.* linseed and cotton stalks, plantain fibre, etc. While stress is being laid on the use of wastes, it should not be made an absolute rule where quality and prices are of the first and foremost importance. In such case if the wastes do not give the desired product then they should not be used. In short the aim of the manufacturer should be to get the suitable raw material at the cheapest prices. The supply of the wastes or other materials must be constant and easily available. For this reason and also for the cost of transport preference should be given to such materials as are available in the locality or within easy distance of the factory.

Next to raw materials is the question of labour. In fact in the production of paper, labour counts much, in as much as two-thirds the cost of production is spent on labour. Care should be taken to see that the labour is not unduly wasted or overspent in any of the processes. At the same time it must

be seen that its efficiency is maintained. The arrangements for carrying out the processes should also be such that there is no hindrance in carrying the processed goods from one operation to another in succession. If the arrangements are not systematic then labour is unduly spent and this increases the costs unnecessarily. Money spent on any kind of labour has got to get its due return in the kind of work. Labour required to sort or cut the material has a different value from labour required in paper lifting or paper polishing. In order that the factory may be efficient, it is but necessary to have a control at every stage of the process, so that no labour or raw material is wasted. The products of every process and the labour empolyed for each process must have some co-relation, otherwise the production in certain processes may be greater or less than the consumption of such processed goods in the subsequent stages, which may result either in unnecessary wastage of labour or material. It is needless to emphasise on the quality of goods. The aim of production must be to bring out goods of standard qualities which will find a ready market. They must also be in attractive form.

Generally the manufacturer has to face the problem of distribution and transport. On the village scale the aim should be to produce such goods as will have a market in the locality or in the vicinity, thereby doing away with the question of competition and increase in cost due to transport. The same may be said about the raw products. It is advisable to get some of the work done on contract basis instead of employing hired labour. In order to fix the contract rate the following data will be useful, it being understood that the working day is of eight hours.

1. *Cleaning and sorting.* 1 man or 2 grown up boys can sort 1 Bengali maund of waste paper or tailor's rags.

2. *Cutting.* 1 man can cut 32 to 40 lbs. of cotton rags or 80 lbs. of gunny wastes.

3. *Trampling and rubbing waste paper to pulp.* An average man can prepare from 15 to 20 lbs. of pulp by this process, washing being separate.

4. *Paper-lifting.* An average vatman with fair speed can produce 400-480 well felted sheets of double fools-cap size or

600-700 sheets of blotting paper, with the assistance of a coucher.

5. *Pressings and drying the sheets.* 2 adults are required to press and dry the sheets made by one vatman.

6. *Polishing.* A man with good practice will glaze 120-150 sheets per day by the old process. In case of calender 2 men can glaze 3 reams of paper, quite easily in a day.

7. *Cleaning.* I man can clean 400-480 sheets of paper per day.

8. *Paper Cutting.* 1 man can cut 3 to 4 reams of paper per day with a sharp steel knife. With a cutting machine the number will be double or treble.

9. *Labour required.* On an average about 10 men are required for the production of one ream of paper.

MAIN REQUIREMENTS OF DIFFERENT UNITS OF PAPER-MAKING FACTORIES

UNIT No. 1

Production about 40-50 lbs. of paper per day, mostly from waste paper.

Floor space required—2000 to 2500 sq. feet including 5′ veranda, approximately distributed as under :

1. Raw material store and preliminary treatment room	... 15′ × 20′	Kachha
2. Boiling Room	... 15′ × 10′	,,
3. Dhenki Room	... 15′ × 13′	,,
4. Five storage tanks . each $2\frac{1}{2}' \times 2' \times 2\frac{1}{4}'$ deep ...	... 15′ × 3′ 3′	,,
5. Trampling and rubbing pits	... 15′ × 7′	,,
6. Washing and storage of pulps	... 15′ × 10′	Pacca wall
7. Paper-lifting room ...	... 15′ × 20′	,,
8. Sizing, finishing etc.,	... 15′ × 25′	,,
9. Office room and finished products storage.	... 20′ × 12′	Kachha Pacca wall

15 × 120 about 1800 s q. ft. excluding veranda.

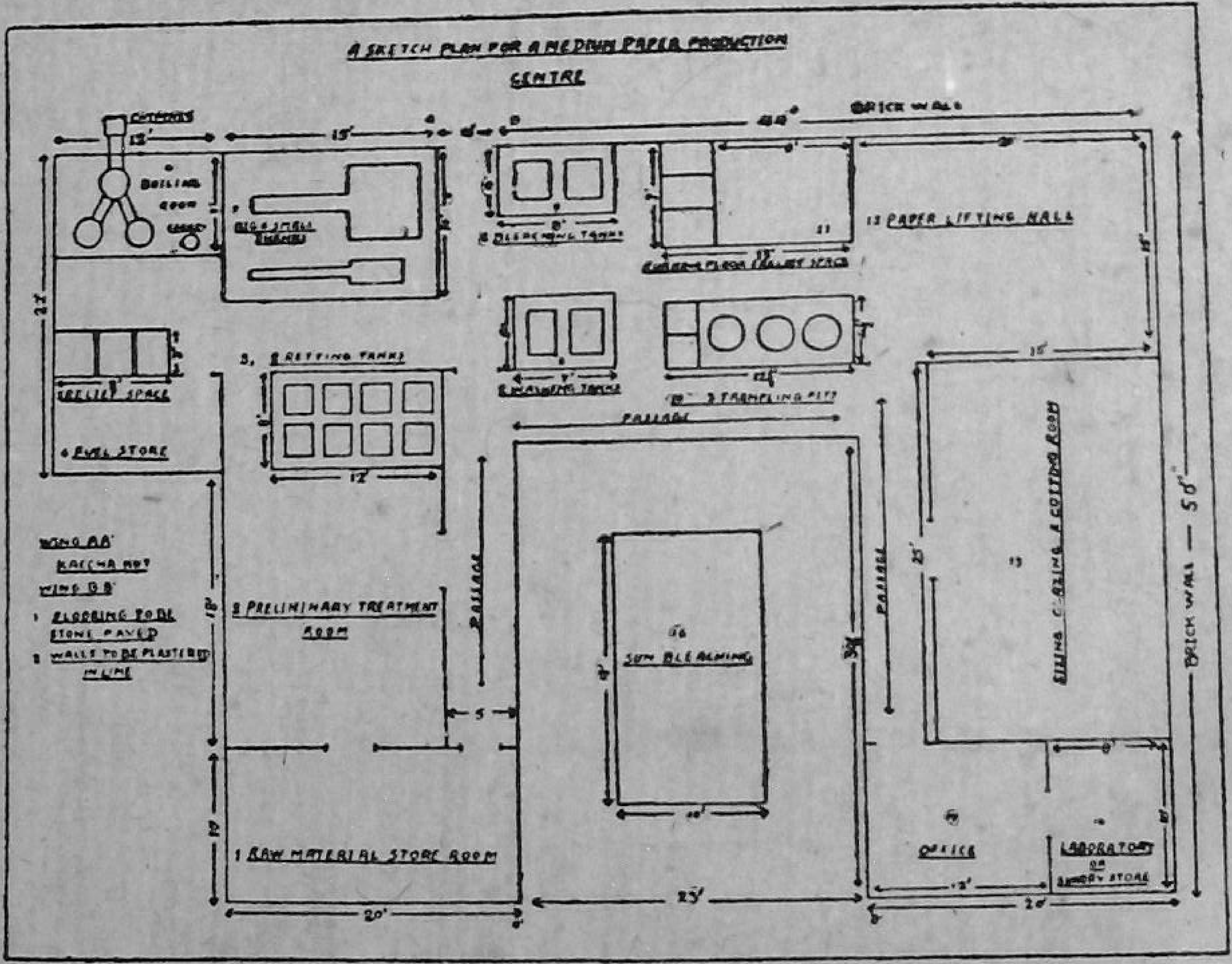


Fig. 14—A Sketch plan for a medium size factory

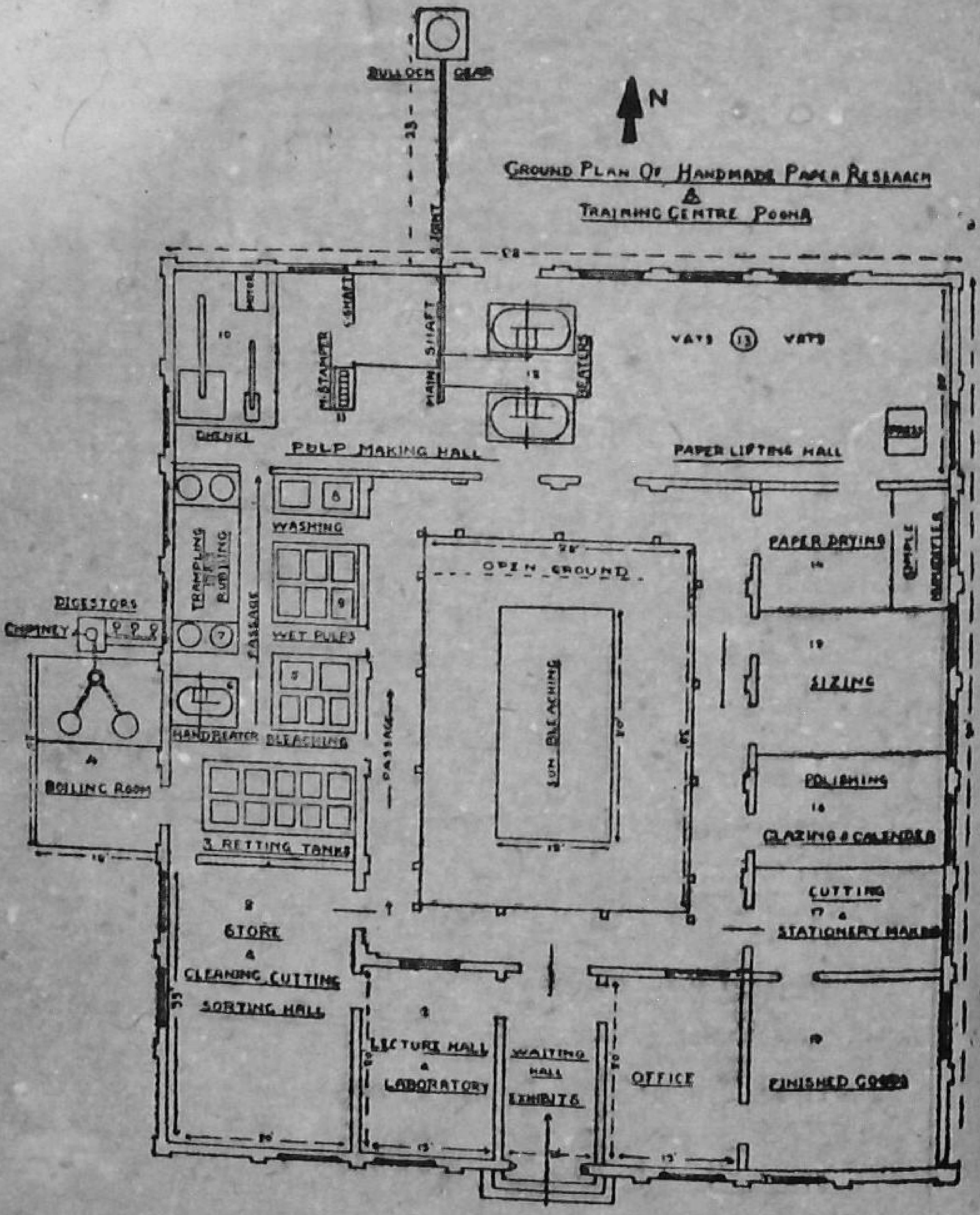


Fig. 15—A sketch plan for a full production-cum-training Centre, Poona

The first two rooms may be separate from the rest of the building. The flooring must be in stone or hard lime-mortar or cement concrete, stone pavement being preferable. In an independant paper factory the plan of the building may be somewhat on the lines of the sketch plan in Fig. 14. But it may be varied according to convenience.

MAIN EQUIPMENT REQUIRED IN THE DIFFERENT PROCESSES

1. *Preliminary treatment room.* Two blocks of wood; 2 axes; 1 grass chopper; 1 wire or bamboo screen or a charpoy.

2. *Boiling room.* 1 open boiler 3′-0 diameter and 4′ high or 2½′ dia. and 3′ high set in suitable furnace or if this is not available 2 empty iron drums of 40 to 50 gallons capacity, set on a furnace or chula. Ash kindling bars and other furnace accessories, 2 or 3 segrees for preparing size etc.

3. *Dhenki Room.* 1 or 2 dhenkis with cisterns and floor as per description in this book.

4. *Trampling and rubbing.* 2 or 4 trampling pits 27″ in dia. and 12″ deep almost dish-shaped with rough inside surface. Rubbing floor should be in stone or plastered with cement. In the centre, trap stone 4′ × 2½′ may be fixed or a rough floor of the same area may be made for actually rubbing the pulps.

5. *Washing and storage room.* 2 wooden tubs 3½′ in diameter × 2½′ deep; 4 storage tanks, each 2′ × 2′ × 1′ high.

Washing. A chaddar 2 yards long × 36″ wide or 2 baskets; or a cradle type wire cloth box 2½′ × 2′ × 1′ – 3″.

6. *Paper-lifting room.* 3 or 4 vats size 4½′ × 3½′ × 3′ deep;
 2 tables on wheels 3½′ × 2½′ × 3′ high.
 2 tables stationary " " "
 2 towel horses 3′ × 9″ × 3½′ high.
 12 paper-lifting frames in different sizes.
 6 couching and pressing boards 3½′ × 2½′ × 1″ thick, or according to the sizes of the paper to be made.
 100 to 200 pieces of clothes. The size of each piece should be about 36″ × 24″ or of appropriate size.

5 or 6 pieces of bamboos for stirring etc.

A screw press, inside size $3\frac{1}{2}'$ long × 3′ broad with 15″ lift for the pressing screw. The plates should be at least $1\frac{1}{4}''$ to $1\frac{1}{2}''$ thick; the screw should be $3' \times 2\frac{1}{2}''$ in diameter or sufficient stone weights, when no screw press is available.

7. *Paper-drying.* Wall surface of about 500 to 600 sq. feet, or ropes 3000 to 4000 feet long and $\frac{1}{2}''$ thick or bamboos. 3 or 4 grass brushes.

8. *Paper-sizing.* A chakki or stone pestle and mortar. 3 or 4 copper pots of 20, 10, 5 and 2 seers capacity. 2 sizing boards $4' \times 3' \times 1''$ thick with wooden supports. 2 or 3 brushes.
   1 wooden sizing tray-hood-shaped-size $3\frac{1}{2}' \times 27'' \times 9''$ deep at the centre, the top being rectangular.
   1 Rectangular wooden tray inside size $3' \times 27'' \times 4''$ high with $\frac{1}{2}''$ cock to remove the pressed size.
   2 wooden boards $34'' \times 25'' \times 1''$ thick to fit inside the rectangular tray for piling and pressing the sheets to remove excess sizing.

9. *Polishing.* 4 burnishers with 4 polishing stones or paper weights. Size of the burnisher—concave board 27" long 8" broad and 6" thick at the ends and $2\frac{1}{2}''$ at the centre with a seat 12" long 8" broad and 10" high supported on two legs; except the legs the burnisher and the seat may be in one piece. Or a calender of two rolls, each 10" to 12" in diameter and 36" long and 2" in thicknes or solid with suitable lever and weight arrangements for pressures.

10. *Cutting.* A table $3\frac{1}{2}' \times 2\frac{1}{2}' \times 1\frac{1}{2}'$ high.
   2 paper cutting knives 12" long and $2\frac{1}{2}''$ to 3" broad.
   Boards made to the size of different paper.

MISCELLANEOUS

1. 6 buckets.
2. 6 baskets.
3. 1 iron pestle and mortar.
4. Fine sieves.
5. 12 gunny bags.

6. 50 bamboos.
7. 6 bamboo or palm mats.
8. Cotton or hemp ropes and coir and Jute yarn.
9. 4 shelves.
10. 2 cupboards.
11. 2 or 3 boxes.
12. 2 pair of scissors.
13. 2 stools.
14. 1 ladder.
15. 4 tinpots.
16. 1 centigrade thermometer.
17. 1 Boumė hydrometer.
18. 1 measuring glass.
19. Needles etc.
20. 1 mat-making frame.

The above requirements are given for an independent factory, using mostly waste paper as raw materials. Pulps from other wastes may be used in small quantities with the waste paper. Beating of such pulps being done under the dhenki. They may be modified according to individual requirements and facilities. This is also true of building, which may or may not be so elaborately planned. The washing and boiling may be done outside the building to save built-up space.

Owing to abnormal conditions due to war, it is not possible to give exact estimates as they may vary from place to place. However, the approximate cost of the built up area will be (2000 × 3½) Rs. 7,000/- or so. The cost on account of the implements, except the boiling tanks, calender and press for which see Unit No. 2, will be Rs. 2000 or so.

APPROXIMATE MONTHLY CONSUMPTION OF MATERIALS

Waste paper and other raw materials	1 ton.
Soda ash ...	1¾ mds.
Lime ...	20 seers (not absolutely necessary.)
Fuels ...	10 maunds.
Rosin ...	1 maund.

Alum (Chemical) or	...	$1\frac{1}{2}$-2 maunds.
Bazar alum	...	13 seers.
Wheat	...	4-5 maunds.

The number of labourers including men, women and children will be from 16 to 20.

UNIT No. 2

(Power pulp unit daily producing 40 – 50 lbs. of rag paper or 80 lbs. of paper from other wastes.)

Space requirements about 2500 sq. ft.

1. Raw Material storage and preliminary treatment room	...	25' × 20'	Kachha.
2. Boiler room	...	15' × 10'	,,
3. Storage tanks and miscellaneous space with 5 tanks, each 2' × $2\frac{1}{2}$' × $2\frac{1}{4}$'	...	15' × 10'	Pucca.
4. Beater room	...	20' × 30'	Pucca.
5. Paper lifting and Pulp storage, etc.		15' × 25'	Pucca.
6. Sizing, finishing etc.	...	15' × 25'	Pucca.
7. Office	...	15' × 20'	Pusca.

MACHINERY

		COST
1. 2 Beaters rolls 26" dia. × 20" wide, knives 56 or 60. Bed-plate knives 6. One roll with sharp knives beating edge of $1\frac{1}{8}$" face. One roll with blunt knives with 3/16" or 1/4" face...........2 × 1500		Rs. 3,000—0—0
2. 2 beater troughs 9' long 4' – 9" broad and 18" deep ... 2 × 600	...	Rs. 1,200—0—0
3. 1 calender 2 rolls dia. 12" × 3' long	...	Rs. 1,800—0—0
4. 1 Press ...	...	Rs. 1,500—0—0
5. 1 Electric Motor of 12 H. P.	...	Rs. 1,200—0—0
6. 1 Boiler $2\frac{1}{2}$' dia. 3' high	...	Rs. 500—0—0
7. 1 furnace and chimney for boiler	...	Rs. 500—0—0
8. Miscellaneous fitting, shafting pullies etc.		Rs. 1,000—0—0
		Rs. 10,700 or say

Rs. 11,000—0—0

The other equipment as in unit 1 ...Rs. 2000—0—0

Building ...Rs. 10,000—0—0

Approximately Rs. 23,000—0—0

The other requirements will be almost the same as in 1. This would produce about 50 lbs. rag paper or 80 lbs. of paper from paper wastes or other raw materials.

Note :—If pressure boiling is required for treating other raw materials 4 digestors each of 5 gallons capacity may be erected in the boiler room.

UNIT No. 3

Production about 100-112 lbs. of rag or 160 lbs. of other paper. The floor space will be about 4000 sq. feet. The general width of the building will be 20' instead of 15'; the space for the beaters and one calendar and motor will be 25' × 35'.

MACHINERY REQUIREMENTS

1. 2 *Beater rolls* (one sharp and one blunt) 30" dia. × 24' width. No. of blades 64 to 72; axle 9' × 3½" dia; Total wt. of roll—1 ton. No. of blades in bed-plate 8.

2. *Beater trough.* 10'-6" long; 5'-5" broad and 20" deep.

3. *Power required* will be 25 H. P.

Except beaters the other requirements will be the same as in unit No. 1 and No. 2 with proportionate increase in them. The number of labourers will be about 30-35. For pressure boiling, 6 or 8 digestors may be used or one big digestor of 3' dia. × 4' high may be used but it will be governed by the boiler act. The cost of building and equipment will be about Rs. 32,000 or so.

Note :—The requirements and estimates given in this section are simply meant to give an approximate idea and should not be taken as final. In starting a factory, loeal conditions, suitability of space and other facilities will have to be taken into account. Due to war and black market the prices also may vary from place to place.

Appendix A

DETERMINATION OF THE APPROXIMATE PERCENTAGE OF PULP OBTAINABLE FROM ANY RAW MATERIAL

(1) Take an exactly weighed amount of the raw material, say 10, 20 or 40 tolas, weighing it in a goldsmith's balance. Then clean and sort it and cut into small pieces and again weigh it. Call this weight B as against the original weight A. The difference between the two weights A—B will be the loss due to cleaning.

(2) Next soak the cleaned material in water just sufficient to moisten and soften it and if hard bruise it in an iron or stone pestle and mortar. Boil the bruised material in sufficient quantity of water for one hour after which filter it through a piece of cloth and wash. Dry the material in the sun taking care that none of it is lost and no dust or any foreign material enters into it. Weigh the dried material accurately in a goldsmith's balance. Again dry and weigh it as before. Repeat this till the weight remains constant. Call this weight C. The difference between the weights B—C gives the loss due to the water soluble components of the fibre.

(3) Boil the material from the last operation in a sufficient quantity of 1·0% caustic soda solution for one hour. Then filter it through cloth as before and wash till it is free from the soluble compounds which can be judged from the absence of any colour in the washed water. Dry the material in the sun and weigh as before till the weight is constant. Call this weight D. The difference between the two weights C—D will give the matters soluble in caustic soda solution.

(4) Repeat the above process of boiling in caustic soda solution a second time and note down any difference between the two treatments. Call the average weight E.

(5) The material from the above treatment should be moistened with water and treated with 5.0% bleaching powder dissolved in water, following the same precau-

tions in making the bleaching powder solutions as described elsewhere. Keep the material in this solution for 5 to 6 hours stirring occasionally. Afterwards wash in plenty of water till it is free from the bleaching solution. If the material is not white enough then it should be boiled with 1.0% soda ash solution for 15 minutes, washed well and again treated with 5.0% bleaching powder as before. The process of bleaching, washing and boiling with soda ash solution is repeated till the material is white. The material so treated is washed in plenty of water and dried in the sun till the weight is constant. Call this weight F. The difference in weights E—F will give an idea about the bleachable matter in the material.

Note—After the last bleaching when the pulp becomes white it should not be boiled with soda ash solution.

A careful observation of the above results and their interpretation will indicate the nature of the treatments that should be given to the material in question and the percentage of the cellulose or pulp that can be obtained from it. The percentage of the cellulose can be found out by the simple rule of three. It is $\frac{F}{A} \times 100$ where F is the weight of bleached cellulose and A is the weight the of original material

ANALYSIS OF PAPER-MAKING FIBRES

(Cross & Bevan's method)

In order to obtain average results a fairly representative sample should be taken for analysis. All the operations are required to be made on separate portions from the sample. The fibrous substance should be cut into 1" lengths. In case of harder substance like bamboo, they should be crushed to splinters and then cut as above. Duplicate results should be taken for comparison of each operation, each time using 10 or 25 grams of the material exactly weighed on an analytical balance. The results should be calculated in percentage on air-dry or oven-dry basis.

Composition of the fibre :—

(1) *Moisture.* Weigh-exactly 10 or 25 grams of the substance and dry it in an oven at 100° C, till its weight is constant.

$$\text{Moisture per cent} = \frac{\text{Loss in weight} \times 100}{\text{Original weight taken.}}$$

(2) *Ash.* The dried or original substance is incinerated in a silica or platinum dish. Cool in a dessicator and weigh. Repeat to constant weight.

$$\text{Ash per cent} = \frac{\text{wt. of the ash} \times 100}{\text{wt. of the original material}}$$

(3) *Oils and fats.* 10 grams of the original substanee are dried in an oven and extracted in a Soxlet apparatus with ether, till all the fatty matters are extracted. Generally it takes from 3 to 4 hours for extraction. Evaporate the ether and dry the residue to constant weight in an oven at 105° C.

$$\text{Percentage of fatty matters} = \frac{\text{Weight of the extract} \times 100}{10}$$

(4) *Alkali solubles.* (a) Alpha hydrolysis : 10 or 25 grams of the air-dry substance is boiled in 15-20 parts of one per cent strength caustic soda solution for 5 minutes and washed through fine bleached muslin cloth in a funnel or through a fine bronze seive (70 No.), till it is free from the coloured liquid of alkali. Squeeze the remaining water and dry the substance at 100° C in the oven to constant weight. Alkali

$$\text{solubles in alpha hydrolysis in p.c.} = \frac{\text{Diff. in weight} \times 100}{\text{Original weight.}}$$

(b) Beta hydrolysis :

Repeat the above using separate portion of the substance and boil it for one hour instead of 5 minutes.

$$\text{Alkali solubes in Beta hydrolysis in p.c.} = \frac{\text{Diff. in weight} \times 100}{\text{The original weight}}$$

(5) *Cellulose.* Boil 10 or 25 grams of the air-dry substance for one hour in 1% caustic soda solution as before. Wash till it is free from alkali. Squeeze out the water. Separate the

lumps as far as is possible and put it in a wash bottle. Pass chlorine, previously washed through water to make it free from hydrochloric acid which is injurious to cellulose, for one hour into the substance. It will be noticed that the substance becomes yellowish brown in proportion to the lignin present in the substance. This is due to chlorine combining with the lignin. The Chlorinated substance is next washed with water and boiled for 10 minutes in 2% solution of sodium sulphite crystals to which a few drops of 1% strength caustic soda solution are added. The solution assumes a reddish brown or magenta colour due to the solution of the lignin chloride into the sulphite. Wash completely and put the substance in a very weak solution of bleaching powder for about two to three hours to remove the residual colour from the cellulose to make it white. Wash the cellulose till it is free from bleaching powder. Dry it in the oven at 100° C to constant weight.

$$\text{Cellulose p.c.} = \frac{\text{The weight of the cellulose} \times 100}{\text{The original weight}}$$

Lignin p. c. = Per cent weight of the oven-dry substance in the Beta hydrolysis – (minus) per cent weight of the oven-dry cellulose.

Note:—As the moisture contents of the fibres vary in different climatic conditions, all the analytical results should be found out at the same period. They must not be performed at wide intervals.

Instead of oven drying, the results may be calculated on air-dry basis in which case moisture will not be taken into account. In cases of harder fibres the chlorination method is repeated two or three times before obtaining pure cellulose.

DETERMINATION OF THE α β, AND γ CELLULOSE FROM A PARTICULAR RAW MATERIAL

The cellulose from the raw material should be separately obtained in sufficient quantity for various determinations by the chlorination method. It should be air-dried and not oven-dried.

Moisture and ash may be determined as before.

Alpha cellulose. This is determined by the marcerization reaction on cellulose. 10 grams of the air-dry material are well mixed with 500 c.c. of 17. 5 p. c. strength of 40° Tw or 24° Be' solution of caustic soda for exactly half an hour. The mixture must be well churned or mixed. At the end of this period it is mixed with 50 c.c. of water and filtered into a Buckner flask through a Buckner funnel using bleached cloth instead of paper for filtration. Suction is applied through a filter pump to aid filtration. The residue on the funnel is washed with plenty of distilled water till it is free from alkali. The fibre is next washed with dilute acetic acid and finally with distilled water and dried in the air to constant weight. This represents alpha cellulose in the air-dry material. The result may be calculated in per cent on air-dry basis.

Beta cellulose. To the filtrates from above add sufficient acetic acid till all the alkali is neutralized and heat it on a water bath till the precipitate coagulates. This is filtered and washed through bleached muslin cloth and dried in the air as before. The results may be calculated as above. This gives the p. c. Beta-cellulose in the original cellulose.

Gamma Cellulose. Is found out by difference between the original cellulose and Alpha and Beta cellulose added together.

DETERMINATION OF THE P. C. CONSUMPTION OF ALKALI AND BLEACH REQUIRED FOR TREATING THE MATERIAL

Open boiling system. In the determinations of the alkali solubles in the Beta hydrolysis of the fibre, the exact amount of caustic soda added to the fibre should first be calculated by titration methods. At the end of the operation of boiling for one hour, all the filtrates as well as the washing are collected together, cooled and made to a definite volume from which the unused alkali may be calculated by titrating a definite volume as usual with standard acid. The difference in weights gives the alkali consumed. The results should be calculated in p. c. of alkali consumed.

Digestion system. 1000 or 2000 grams of the material should be digested with sufficient but definite amount of

caustic soda solution of 2.0 or 3. 0% strength. The amount of caustic soda added should be found out by titration methods. This mixture is digested at 30, 40 or 50 lbs. pressure for 4 hours. The digested material is washed completely. All the washings and the digested liquids are collected together and made to a definite volume in gallons or litres. In the former case the contents should be converted into litres by the conversion factor 1 gallon = 4.546 litres. From this the amount of the unused alkali may be found out by titration method and percentage of alkali consumed may be found out.

Bleach test. The material from either of the above treatments should be mixed with a definite and sufficient amount of bleaching solution, whose bleaching powder contents are previously known. Immediately after mixing the stuff with the solution a definite amount 5 c. cs should be titrated with a standard solution of sodium-thio-sulphate and the result of the titration in c.c. used noted. To ascertain the bleaching progress 5 c. cs from the mixture should be titrated against Na_2 S_2 O_3 solution from time to time. This should be continued till the pulp is white or of the desired appearance in colour. The results may be calculated as under :—

P. C. of bleaching powder consumed = Original wt. of bleaching powder × (1st reading in c.cs.—last reading in c.cs. of $Na_2S_2O_3$) × 100 ÷

(1st reading of titration in c. cs.) × original weight of fibre either boiled or digested.

The optimum conditions of the pressures for digestion with minimum consumption of bleaching powder can be determined by varying the conditions of digestion at different pressures and for different periods.

CELLULOSE CONTENTS IN DIFFERENT RAW MATERIAL

Percentage loss over the original material

Raw Material	*1* *1 hour boiling in plain water*	*2* *1 hour boiling in 1% caustic soda solution*	*3* *1 hour chlorination from 2*	Cellulose percentage
1. Cotton unclean	2	10	15	85
2. Sunn-hemp	2.5	23.5-24	28-29	72-73
3. Linseed fibre crude	×	35.0-35.6	53.6-58	42.0-46.4
4. Sisal hemp	3.0-7.2	16.0-20.0	34.0-36.0	64.0-66.0
5. Old bamboo waste	12.0	32.5-34	55.0-56.5	43.5-45.0
6. Old manila rope	12.5	29.0	39.0	61.0
7. Old jute waste	15.0	30.0	45.0-47.5	52.5-55.0
8. Rice straw	18.0	47.5	57.5	42.5
9. Moya grass	7.5	43.75	64.0-65.0	35.0-36.0
10. Bul-rush	20.8	39.2	72.0	28.0
11. Murad sing (Heliacters Isora)	20.8	...	65.2	34.8
12. Rameta bark	×	40.0	52.8-57.5	42.5-47.2
13. Nim bark	×	...	75.2	24.8
14. Antiaris Toxicaria Valkal tree	×	...	...	56.0
15. Cotton stalk fibre	×	...	...	34.0
16. Date palm leaves	×	...	...	17.0
17. Date palm stems	×	...	...	40.0
18. Munj grass	×	...	...	46.0
19. Ficus religiosa	×	...	...	52.0
20. Plantain stem fibre partially cleaned	25.0	57.0	74.4	25.6

These results are taken from students' work and are based on air-dry weights.

APPENDIX B

COST OF PRODUCTION OF PAPER FROM 1 BENGALEE MAUND OF WASTE PAPER AT ONE OF THE OLD PAPER FACTORIES IN BOMBAY PROVINCE (1941—42)

	Rs.	A.	P.
1 Bangalee maund raddi waste paper at Rs. 4.8.0 per Bengalee maund	4	8	0
Paper obtained is 5 to 6 guddies *i.e.* 3 reams of double foolscap size or 3½ guddies *i.e.* 1¾ ream of paper, size Bahaddurkhani...25"×28"			
The total weight of paper obtained is 60 lbs			
Soap, lime, washing soda	1	0	0
Alum ... 2 lbs. ... Rs. 0-4-0 ...	0	8	0
Wheat for sizing-20 lbs. ... Re. 1-4-0 ...	1	12	0
Labour :—			
Sorting and cleaning (This is done by old men in the kagazis' houses) anna one per day for three days ...	0	3	0
Washing, rubbing and pulp-making...by contract 2 men for 5 to 5½ days at Rs. 4/-per Bengalee maund ...	4	0	0
Paper-making...... by contract...As. 12 per guddi of 240 sheets ...	4	8	0
Vatman's assistant (a small girl to put the cloth on the wet sheet over the Mould) 1 anna per 240 Sheets or one guddi ...	0	6	0
Paper drying......by contract......As. 5 per guddi ...	1	14	0
Paper cleaning with pumice stone...As. 1 per guddi ...	0	6	0
Sizing......by contract ... As. 4 per guddi ...	1	8	0
Glazing ... ,, ... ,, 8 per guddi ...	3	0	0
Cutting ... ,, ... ,, 1 per guddi ...	0	6	0
Filling vat with water ,, ... ,, 1 per guddi ...	0	6	0
Paper mat, cloth and depreciation on tools ,, ...	0	6	0
	24	11	0

The total cost of conversion of one Bengalee manud or waste paper into serviceable paper comes to about Rs. 24-11-0 for six guddies or three reams of double foolscap size. The average cost per guddi comes to Rs. 4-4-0 to Rs. 4–8–0. of Rs. 8-8-0 to Rs. 9/-per ream of 480 sheets of double foolscap size. The double foolscap size ream fetches between Rs. 12 to Rs. 13-0 per ream. Calculated on this basis the net sale proceeds come to about Rs. 36/—It takes about five days for about 10 labourers including the vatman for converting one Bengalee maund of paper waste into the finished product.

Note:—If the kagazi makes 360 sheets of paper as against his present system of making only 240 sheets per day and if he makes the pulps by trampling in pits and finally rubbing on the floor as against his present practice of making the pulps only by rubbing, his factory will be in balance with the other processes. He can finish the work in three days, thereby increasing his productive and earning capacity in like proportion.

SOME PULP AND PAPER-MAKING DATA

Blotting paper from old rags

(Open Boiling)

Material		*Quantity*
Raw Material	...	120 lbs. (1½ mds.)
After cutting	...	109 lbs. (loss 11 lbs.)
Caustic Soda	...	5½ lbs.
Bleaching powder	...	nil.
Wood fuel (dry) for 4 hours boiling	...	1 maund
Colour	...	3½ tolas
Water	...	4000 gallons

Labour		*No. of Men*	*No. of days*
Cutting, sorting & cleaning		1	4
Boiling	...	1	1/2
Beating, washing etc.		1	1½
Electric units consumed		19 K.W.	

Paper-lifting		*No. of Men*	*No. of days*
Vatman	...	1 }	2
Coucher	...	1 }	
Assistants	....	2	2
Paper cleaning	...	2	1
Sheet calendering	...	2	1/2
Sheet cutting	...	1	1
Miscellaneous	...	1	1

No. of sheets1080 Size...... $\dfrac{17\frac{1}{2}\times\text{''}\ 22\frac{1}{2}\text{''}}{\text{Demy size}}$ wt. 74 lbs.

i. e. 2¼ reams, each ream weighing about 33 *lbs.*

The total pulp obtained is 79½ lbs.

Colours used chlorazal fast scarlet 4 BS, 3 tolas

Methyl violet. 1/4 „

BLOTTING PAPER

Old records and printed waste.

(Trampling and rubbing process).

Material		*Quantity*
Old books, printed forms etc.		100 lbs.
Caustic soda	...	3 lbs.
Soap for washing	...	1 lb.
Colour—Congo red and Imperial red		3 tolas
Fuel for heating water	...	10 lbs. of coal
Water	...	2500 gallons

Labour		*No. of Men*	*No. of days*
Sorting & cutting	...	3	1
Retting	...	1	½
Trampling and rubbing	...	4	1
Washing	...	2	1
Mixing colour and final beating in beater 1 hour—electric units	...		1½

Paper-lifting		*No. of men*	*No. of days*
Vatman	...	1	1¼
Coucher	...	1	1¼
Asstts. for pressing, drying		2	1½
Paper cleaning with pumic stone	...	1	1½

Calendering	...	2	½
Cutting	...	1	½
Miscellaneous	...	1	1
Pulp obtained	...		54 lbs.

Paper obtained... 17½" × 22½" / Demy size : 600 sheets. wt. 49 lbs,

Paper wastage	...	...	3½ lbs.
Residual pulp	...	...	1½ lbs.

Note :—This is an average data. The maximum speed attained for lifting blotting paper, is about 650-700 sheets per day of 8 hours. In case the pulps are entirely made in the beater, labour on account of trampling, rubbing washing etc., will be reduced ; similarly instead of retting, the waste paper may be boiled in which case, the fuel required will be about 60 lbs. of wood in an economic furnace.

PULP FROM PRESS CUTTINGS

Material (original)	...	70 lbs.	Loss 12/lbs.
after sorting	...	58 lbs.	
Caustic soda	...	1½ lbs.	
Fuel for hot water	...	10 lbs. of coal.	
Water	...	2006 gallons.	
Labour		*No. of Men*	*No. of days*
Sorting, cutting etc.	...	2	1
Retting and miscellaneous	...	1	1/2
Beating for 1/2 day electric units		3 units	
Beater attendant		1 man	1/2
Washing outside the beater		2 men	1
Pulp obtained	...	38½ lbs. *i. e.* 66.4% on	

sorted material or 55.0% of the original raw material.

PULP FROM EXAMINATION ANSWER BOOKS

(Boiling, trampling and rubbing process)

Material		*Quantity*
Examination books	...	20 lbs.
Caustic soda	...	10 ozs.

Fuel for boiling water	...	10 lbs. of coal	
Water	...	700 gallons.	
Bleaching powder	...	3/4 lb.	
Labour	*No. of Men*		*No. of days*
Cutting, cleaning	1		1/2
Boiling	1		1/2
Trampling and rubbing	1		$1\frac{1}{2}$
Washing	1		1/2

Pulp obtained was 14 lbs. or 70-0%.

COST OF CONVERSION OF ONE BENGALEE MAUND OF

Tailors white cuttings into paper

Pulp-making

Material	*Quantity*	*Rate*	*Cost*
Rags	82 lbs.	@ 0-2-0 per lb.	10-4-0
Rags after cutting	78 lbs.	(loss 4 lbs.)	
Caustic soda for boiling	3 lbs.	@ 0-8-0 per lb.	1-8-0
Bleaching powder	3 lbs.	@ 0-8-0 per lb.	1-8-0
Fuel : in the economic Furnace	40 lbs.	@ 2-0-0 per md.	1-0-0
Water	3000 gals.	0-8-0 per 1000 : gals.	1-8-0
Labour			
Cutting charges	...	@ 0-0-6 per lb.	2-8-0
1 *boiler attendant* for 1 day	...	@ 0-12-0 per day	0-12-0
Beating, Washing & bleaching : 1 man 3 days	...	@ 1- 8-0 per day	4- 8-0
Electric units consumed 60	...	@ 0- 1-0 per unit	3-12-0
Miscellaneous labour etc. 1 man 1 day		: 0-12-0 per day	0-12-0
A......Total cost of pulp-making			Rs- 28-0-0

Total pulp obtained 60 lbs.

Cost of the pulp will come to about *annas* $7\frac{1}{2}$ per lb.

Brought forward...A...Pulp-making ... Rs. 28-0-0

Labour	*No. Men*	*No. Days*	*Rate per day*	*Cost*
Vatman	3	1	1—8—0	4—8—0
Coucher	3	1	1—0—0	3—0—0
Asstts. for pressing & drying	5	1	0-12—0	3-12—0
Paper cleaning	3	1	0-12—0	2—4—0
Sizing	2	1	0-12—0	1—8—0
Glazing (calendering)	2	1	0-12—0	1—8—0
Cutting	1	1	0-12—0	0-12—0
Miscellaneous	2	1	0-12—0	1—8—0

B......Labour cost...... Rs. 18-12-0 : 18-12-0

Sizing materials	*Quantity lb*	*Rate per lb.*	*Cost*
Glue	10	1-0-0	10—0—0
Alum	$1\frac{1}{2}$	0-8-0	0-12—0
Soap & misc.			0—8—0

C......Cost of sizing... ... Rs. 11-4—0 11-4-0

Adding A + B + C total Cost ... Rs. 58—0—0

Supervision, depreciation @ 30% Rs. 17—6—0

Paper (glue sized) produced 66 lbs Rs. 75—6—0

Less wastage of paper at 30%
recoverable as small note paper etc. 20 lbs.
@ 0-9-0 per lb. Rs. 11-4-0

Total saleable paper 46 lbs...... „ 64-2-0

The cost of the rag paper per lb. comes to Rs. 1-6-6

The number of reams demy size : $17\frac{1}{2}$'' × $22\frac{1}{2}$'' each ream weighing about 30-32 lbs..............$1\frac{1}{2}$ reams.

Or the cost per ream will come to *about* Rs. 43/-

CONVERSION OF OLD MANILA ROPES INTO WRITING PAPER

Material		*Quantity*
Manila ropes	...	40 lbs.
Digested in 10 lots of 4 lbs. each at 30 lbs. pressure for 5 hours.		
Caustic soda...	...	5 lbs. 8 ozs. or 13.25%
Coal consumed		45 lbs.
Bleaching powder 30% chlorine		2 lbs. or 5.0%
Pulp bleached to creamy white colour.		
Water	...	1500 gallons.

Sizing materials		*Quantity*
Rosin	...	1½ lbs.
Alum	...	2½ lbs.
Starch	...	1½ lbs.
China clay	...	1 lb.

Labour		*No. of Men*	*No. of Days*
Cutting and cleaning	...	1	4 hours.
Digestion	...	1	2½ days.
Beating, washing & bleaching for 8 hours	...		
Electric units	...	10 k. w.	
Beater attendant and Miscellaneous	...	1	1
Paper-lifting			
Vatman without coucher	...	1	2
Asstts. for drying, pressing etc.—	...	3	1½
Cleaning the dry sheets		1	1½
Calendering	...	2	½
Sheet cutting	...	1	½
Miscellaneous	...	1	1

Product obtained		
Sized pulp	...	30 lbs.
D. F. sheets 650	...	28 lbs.
Pulp wasted as residual pulp		2 lbs.

PULP FROM CRUDE SUNN-HEMP

(Fractional digestion).

Raw material	*Quantity*
Crude Sunn-hemp fibre ...	56 lbs.
Cleaning and cutting ...	54 lbs. (loss 2 lbs.)
Caustic soda for open boiling 3 hours	2 lbs. 4 ozs. 4.0%
Digestions 8 lots each for 4 hours at 40 lbs. pressure :	
Caustic soda ...	6 lbs. 4 ozs....12.0%
Fuel for boiling & digestion ...	2 maunds of wood.

After digestion the stuff was grayish white.

Bleaching powder 2.27% strength	10 lbs. (3/4 to 1 lb. normal bleaching powder)
Soap	1 lb.
Water	1500 gallons

Labour	*No. of Men*	*No. of days*
Cutting & cleaning ...	1	1/2
Boiler & digestor attendance ...	1	2½ days
Beating, bleaching, washing		
Electic units required in 12 hours. ...	18 k. w.	
Attendant ...	1 man	1½ days
Pulp obtained ...	30 lbs....or 55.0%	

The pulp was white and well hydrated.

PULP-MAKING FROM FISHING NETS (SUNN-HEMP) (FRACTIONAL DIGESTION)

Material	*Quantity*
Fishing nets ...	52 lbs.
After cutting and dusting ...	48 lbs.
Open boiling : Caustic soda ...	2 lbs...4%
Wood fuel for 4 hours ...	35 lbs.
Digestions 4 for 6 *hours at* 40 *lb.* pressure.	
Caustic soda. ...	4 lbs...8%
Wood fuel required. ...	1 Bengalee maund.

Bleaching powder (*Low grade 2.27%* strength)	...		7 lbs.
Concentrated Hydrochloric Acid	...		1/2 ozs.
Sodium Sulphite 5% solution	...		2 ozs.
Washing soap	...		12 ozs.
Water	...		1500 gallons.
Labour		*No. of men*	*No. of days.*
Cutting, sorting, cleaning		1 woman	1 day.
Boiling and digestion loading and unloading		1 man	$2\frac{1}{2}$ days.
Beating for 12 hours			
Electric units consumed	...		19 units
Beater attendant		1 man	$1\frac{1}{2}$ days
Miscellaneous		1 man	1/2 day
Pulp obtained		24 lbs.	46.0%

This pulp was mixed with 25 lbs. of new-rag pulp. This was used for DRAWING PAPER.

Out of the drawing papers 50 sheets demy size wt. 7 lbs. 12 ozs. were sized with glue as under :—

2 lbs. of glue and 5 ozs. of alum were dissolved in hot water at 60°C. The solution weighed 36 lbs. 12 ozs. The paper was made flat by hard pressing before sizing. After sizing the sheets were pressed in a screw press (light). The liquid sqeezed out weighed 23 lbs. 4 ozs. *i. e.*, the p. c. of glue taken by the paper was $\frac{13 \text{ lbs. } 8 \text{ ozs.}}{36 \text{ lbs. } 12 \text{ ozs.}} \times \frac{2 \times 100}{7 \text{ lbs. } 12 \text{ ozs.}} = 9{\cdot}5\%$

Sized sheets on drying weighed	...	8 lbs. 8 ozs.
Deduct wt. of original paper		7 lbs. 12 ozs.
Increase in wt.	...	0—12 ozs.

Glue required for sizing $= \frac{12 \text{ ozs.}}{7 \text{ lbs. } 12 \text{ ozs.}} = 9{\cdot}670\%$

Note :—This drawing paper was found to be better for artists purpose than the rag drawing paper. It stands erasure with rubber and colour washes with the artist's brush, for a longer period.

Fishing nets and the crude sunn-hemp fibre in the data were fractionally digested. This consisted of removing a part of the non-cellulose matters by open boiling at atmos-

pheric pressure, with partial amounts of caustic soda. After washing the material was subsequently digested under pressure with the remaining caustic soda. The stuff was almost grayish white and consumed very little normal bleaching powder. This method is preferable to that of over head digestion in which the material is digested in one operation with the full quantity of caustic soda. In the latter case the bleaching powder consumed is greater than in the former case.

PAPER FROM GUNNY WASTE (old cement bags)

Raw material	... 1 maund or 82 lbs.
Lime	... 18 lbs.
Soda ash	... 24 lbs.
or	
Caustic soda	... 12 lbs. or 15 lbs.
Fuel in boiling for 6 hours	... 61 lbs.
Bleaching powder 30 per cent strength	... 10 lbs.
Pulp obtained	40 lbs. (unsized)
Sizing materials	
Rosin ...	... 2 lbs.
Alum ...	... 3 lbs.
China clay ...	... 3 lbs.
Paper obtained	... 1000 sheets demi-size weighing 44 lbs.
Residual pulp (sized)	... 3 lbs.
LABOUR :—	
1. Cutting, sorting & cleaning	... 1 man for 1 day
2. Boiling	... 1 man ,, ,,
3. Beating for 8 hours in two equal lots of 40 lbs. and 4 hours duration	... 1 man ,, 1 day
4. Electric power consumed	... 14 units.
5. Sheet formation	... 1 vatman 2 days 1 coucher 2 days
6. Sheet drying	... 2 men 2 days
7. Sheet cleaning	... 2 men 1 day
8. Calendering	... 2 men ½ day
9. Paper cutting	... 1 man ½ day

Miscellaneous for sizing etc.		1 man 1 day
Water	...	2000 gallons

STATIONERY PAPER FROM WASTE PAPER & RAGS

Waste paper	*Hosiery rags bleached*	*Cut and cleaned*	*Loss*
120 lbs. +	$35\frac{1}{2}$ lbs.	33 lbs.	$2\frac{1}{4}$ lbs.

Soda ash	5 lbs.	used for waste paper only
Lime	3 lbs.	

The waste paper was boiled.

Fuel consumed in 3 hours	...	45 lbs.
No chemical treatment to rags		
Pulp from waste paper-unsized	...	84 lbs. or 70 per cent
Rag pulp unsized	...	27 lbs. or 76 per cent
Total unsized pulp	...	111 lbs.
Sizing ... Rosin ...	...	5 lbs.
,, ... Alum ...	...	$7\frac{1}{2}$ lbs.
China clay	...	8 lbs.
Colour chlorazol green	...	1 oz.
Paper obtained ... demi-size	...	1727 sheets weighing 120 lbs. 8 ozs.
Residual pulp	...	2 lbs. 8 ozs.

LABOUR :—

(1) Cutting etc...rags	...	1 man for 1 day
,, waste paper	...	2 men ,, 1 day
(2) Boiling, loading & unloading		1 man ,, 1 day
(3) Beating & washing rags	...	1 man ,, 1 day
waste paper	...	1 man ,, $2\frac{1}{2}$ days
Electric power for rags 33 lbs.	...	26 units
waste paper 120 lbs.	...	17 units
Total	...	43 units.

Note :—The pulps were made separately.

(4) Sheet formation	1 vatman 1 coucher	for 4 days
(5) Sheet drying	2 men	for 4 days
(6) Cleaning	1 man	for $4\frac{1}{2}$ days
(7) Glazing	2 men	for $1\frac{1}{2}$ days
(8) Paper cutting	1 man	for 1 day
(9) Miscellaneous for sizing etc.	1 man	for 1 day
Water consumption		6000 gallons

The wastage of paper in all data in this section is approximately 25 per cent which can be converted into small size paper. Normally wastage for hand made paper should not be more than 15 to 20 per cent.

The various data enumerated in this section are of an experimental nature and are meant as a general guide. While the material data may not appreciably change, the data for labour may vary according to the efficiency of the labourers for which it is desirable to have a continuous production of a uniform variety of paper from the same raw materials. The capacity of the equipment must be taken into consideration in the production costs. One attendant is required for beating whether a beater is of 40 lbs. or 100 lbs capacity. This is also true of boiling and digestion. Except rag paper no costing data is given as they may vary from place to place under the present abnormal conditions. However, the costs can be calculated from the local conditions of wages, cost of materials etc.

APPENDIX C

SOME USEFUL MEMORANDA

Conversion of Centigrade thermometer degrees into Fahrenheit degrees and vice versa

A thermometer is an instrument to measure the degrees of temperatures of solids, liquids and gases. It consists of a glass bulb filled with mercury which expands and rises regularly through a capillary tube attached to the bulb according to the temperatures. It is known that water solidifies turning into ice or boils at definite temperatures.

In the Centigrade thermometer the temperature of the melting ice is taken as 0 degrees C and that of boiling water at sea level is taken as 100 degrees C and the distance of the mercury column between the two points is divided into 100 parts. Each division is called one degree Centigrade; while in the Fahrenheit thermometer, they are taken as 32 degrees F and 212 degrees F respectively and the distance between the two points is divided into 180 parts and each division is called one degree Fahrenheit. To convert Centigrade into Fahrenheit degrees or *vice versa* the formula used is.

$^\circ F$ equals $^\circ C \times 9/5 + 32$.

$^\circ C$ equals $(^\circ F - 32) \times 5/9$

Where $^\circ F$ means degrees in Fahrenheit and $^\circ C$ means degrees in Centigrade.

TEMPERATURES OF BOILING WATER AND CORRESPONDING STEAM PRESSURES IN LBS. (FOR THE USE OF DIGESTORS)

Degrees C	*Degrees F*	*Pressure in lbs.*	*Pressure gauge reading in round figures*
100	212	14·7	0
105	221	17·5	3
109	228·2	20·11	5
110	230	20·80	6
115	239	24·5	10
116	240 8	24·7	10
120	248	28·8	14
121	249·8	29·7	15
125	257·0	33·72	19
126	258·8	34·7	20
130	266	39·26	25
131	267·8	40·47	25
135	275	45·52	30
138	280·4	49·65	35
140	284	52·5	38
141	285·8	54·0	39
142	287·6	55·6	40
145	293·0	60·44	45
148	298·4	65 6	50
150	302	69·26	54
152	305·6	73·06	58
154	309·2	77·03	62
156	312·8	81 22	66
158	316·4	85·47	70
160	320·0	89·96	75

The pressures for digestion mentioned in this book are not absolute pressures, but those indicated by the gauge reading.

HYDROMETERS

Hydrometers are instruments to measure the densities of liquids or solutions of salts in liquids. It consists of a weighted glass bulb to which is attached a glass tube with an inside scale. It floats or sinks according as the liquid is heavy or light which is indicated on the scale divisions. The position where it sinks in pure water is taken as the 0 point on the scale which is at the top for liquids heavier than water. The scale is read from the top to the bottom while for the lighter liquids the zero reading is at the bottom, the scale being read from bottom upwards.

There are two systems of hydrometers in general use. One is called Baume' and the other Twaddle system. The specific gravities of liquids or solutions heavier than water can be found out from the scale readings in the respective system as under :—

Baume' hydrometer : sp. gr. $= \dfrac{144.3}{144.3-N}$

Where N stands for the degrees read on the Baume' hydrometer. The degrees in this system are marked as °Be

Twaddle hydrometer : sp. gr. $=1+\dfrac{5\times n}{1000}$ where n stands for the degrees read on the twaddle hydrometer. The degrees in this system are marked as °Tw. The °mark indicates degrees Thus 5°Be' are read as 5 degrees on the Baume' hydrometer 7°Tw. means 7 degrees on the Twaddle hydrometer.

From the readings on the hydrometers the specific gravities and corresponding percentages of a particular substance in solution may be found out from the tables given for that salt under the respective systems.

SPECIFING GRAVITY, BAUME' AND TWADDLE OF CAUSTIC SODA (*Hurst*) SOLUTION

Baume'	*Twaddle*	*Sp. Gr.*	*Baume'*	*Twaddle*	*Sp. Gr.*
0	0	1·00			
1	1·4	1·007	21	34·2	1·171
2	2·8	1·014	22	36 0	1·180
3	4·4	1·022	23	38·0	1·190
4	5·8	1·029	24	40·0	1·200
5	7.2	1·036	25	42·0	1·210
6	9·0	1·045	26	44·0	1·220
7	10·4	1·052	27	46·2	1 231
8	12	1·060	28	48·2	1·241
9	13 4	1·067	29	50·4	1·252
10	15	1·075	30	52·6	1·263
11	16·6	1·083	31	54·8	1.274
12	18·2	1·091	32	57·0	1·285
13	20·0	1·100	33	59·4	1·297
14	21·6	1·108	34	61·6	1·308
15	23·2	1·116	35	64·0	1·320
16	25·0	1·125	36	66·4	1·332
17	26·8	1·134	37	69·0	1·345
18	28·4	1·142	38	71·4	1·357
19	30·4	1·152	39	74·0	1·370
20	32·4	1·162	40	76·6	1·383

LBS. OF ACTUAL CAUSTIC SODA CONTAINED IN 1 GALLON OF LYE OF DIFFERENT SP. GRAVITIES

Degree Twaddle	*Degree Baume'*	*Sp. Gravity*	*Caustic soda lbs.*
0	0	1·00	
1	0·7	1·005	0·048
2	1·4	1·010	0·097
3	2·1	1·015	0·146
4	2·7	1·020	0·194
5	3·4	1·025	0·243
6	4·1	1·030	0·291
7	4·7	1·035	0·335
8	5·4	1·040	0·389
9	6·0	1·045	0·438
10	6·7	1·050	0·486
11	7·4	1·055	0·536
12	8·0	1·060	0·586
13	8·7	1·065	0·636
14	9·4	1·070	0·680
15	10·0	1·075	0·742
20	13·0	1·100	0·986
25	16·0	1·125	1·238
30	18·8	1·150	1·529
35	21·4	1·175	1·822
40	24·0	1·200	2·122

MENSURATION FORMULAE

1. Area of a rectangle = Length × Breadth.
2. Circumference of a circle

   $= \pi D$ or $2 \pi r$
3. Area of a circle $= \pi r^2$ or $\pi \frac{D^2}{4}$
4. Surface of a drum or cylinder $= 2\pi rh + 2\pi r^2$
5. Peripheri of a drum or cylinder $= 2\pi rh$

Capacities of tanks etc.

6. Rectangular tanks $= L \times B \times h$
7. Cylindrical tank $= \pi r^2 h$
8. Vats...sloping on two sides as in

$$\text{Modern system} = L \times \frac{\text{Top B + bottom B}}{2} \times h$$

where L = length ; B = breadth or width ; h = height; D = diameter ;

r = radius ; $\pi = \frac{22}{7}$

One cubic foot contains = 6.25 gallons or 28.316 litres.
One gallon = 4.546 litres.
1 lb. by measure = 454 cc.
1 inch ... = 25.4 centimeters
1 foot ... = 300.48 ,, ,,
1 yard ... = .914 meters
1 meter ... = 39.37 inches or 3.2808 ft.

Weights

1 lb. by weight = 453.6 grams
1 oz. ,, = 28.346 grams
1 H. P. = .746 units of electric power.
1 Killowatt or Electric unit = 1.341 Horse power.
1 maund of mineral coal = 2 maunds of wood fuel.
1 H. P = 2 bullocks or 6 men.

The boiler capacity for raw materials :—

Each cubic foot holds 12-13 lbs. of rags or 10 lbs. of waste paper or 5 to 6 lbs. of grass, bagasse or sugarcane tops, or 8 lbs.

of gunny wastes when lightly packed. The boiler must have sufficient space for the circulation of liquors. For this, in making the boilers the capacities should be increased by 1/3 of that required for the specific materials to be boiled. A boiler 2½' dia. × 3' high holds about 120-125 of rags or 100 lbs. waste paper or 50 to 60 lbs. of straw or 80 lbs. gunny waste.

APPENDIX D

SCHOOL PAPER-MAKING UNIT

The raw materials from which pulps and paper are made, divide themselves into two classes.

(1) Waste paper, (2) Original fibrous raw materials or their industrial wastes. Out of these the first one is the easiest to convert it into blotting and ordinary writing paper without requiring complicated machinery involving any large capital expenditure. The processes are simple and can be followed easily in school mostly with the house-hold appliances, while the other raw materials are more difficult as they require complicated implements.

The implements and the processes of reconverting waste paper into useful paper are briefly described as under :—

IMPLEMENTS

Cleaning and dusting. A wire gauze sieve or a sieve made of bamboo splinters.

Boiling. A cylindrical vessel about 15" in diameter and 16" to 18" in height or approximately of the same size as an empty 1 cwt. bleaching powder drum; capacity about 11 gallons. It may be of iron or copper or an empty bleaching powder drum or a kadhaya. For smaller quantities even a smaller vessel will do.

Fire hearth as is used for heating water for bathing or cooking or a segri suitable for the vessel.

Another small segri as is used in the kitchen room, for making sizing etc.

Pulp–making. Semi-circular trampling pit made either of cement concrete with rough inside plaster or of stone with sufficient rough surface. The dimensions should be: mouth 24" in diameter and 10" to 12" deep, dish-shaped from inside.

A rubbing floor 6'×5' constructed in shahabad or trap stone or cement concrete, in the centre of which a rough floor of the size 3' × 2' is made either of rough trap stone or of rough cement concrete. If it is desired the floor may be

greater in area. In case this is not possible small quantities of pulps (1 to 2 lbs) can be made in a stone pestle and mortar or by churning with a country butter churn.

Washing. One chadder or dhoti and 2 bamboo baskets.

Bleaching. A small wooden tub or a brick tank plastered with cement or lime mortar and having a capacity of about 11 to 12 gallons or a porcelain jar (barni) for smaller quantities. Pulps may or may not be bleached.

Paper-lifting. One or two wooden tubs of the size 2½' diameter and 1½' deep or bath tubs of the size 3' long, 2½' broad and 1' to 1½' deep.

Moulds for paper-lifting. 2 fools-cap and two half fools-cap size moulds. They may be made of wire gauze or may be of grass mat as explained on pages 93, 102 and 150 in this book. 5 or 6 wooden boards of 24"×20" and 1" thick or even suitable boards for small size paper; 40 to 50 pieces of clothes of the size 24"×18" each in case of fools-cap size paper or in case of the half fools-cap size paper they should be 18"×12".

For squeezing water. A small copy screw press for half fools-cap or smaller size paper or a press similar to that used by the book-binders; or a board and stone weights.

Drying the sheets. Smooth wall surface 10'×2' plastered in lime with one white wash for drying the paper. Or bamboos can be utilized for drying the paper.

Sizing. 2 or 3 copper or brass vessels of the capacity of about 2 seers each. One soft brush or solid ball-shaped cloth bag. (2″ — 3″ in dia.)

Polishing the papers. A concave board of the approximate size of 1½' or 2' long and 8″ broad having a curvature of about 2″ to 3″.

Round or cylindrical glass paper-weights for glazing the paper or an agate stone. or a conch shell.

Cutting & Stationery-making. Wooden boards of the size of fools-cap, half fools-cap and 1/4 fools-cap size paper.

One small table of the size 2' × 3' and 1' in height. The thickness of the top board should be of 1″.

One suitable sharp knife to cut the paper, one pair of scissors. Tin plates cut in suitable sizes of the unfolded envelopes.

Miscellaneous. 5 to 10 bamboos, 3 or 4 baskets, 3 or 4 buckets, 2 or 3 pasting brushes (if available), cotton rope ½″ thick, needles and thread, 2 or 3 stools, bamboo sieve as is used for cleaning grain.

Raw materials. Paper waste such as old examination answer books, exercise books, letters, old records, waste correspondence, paper shavings from printing press the original paper of which was suitable for writing with ordinary inks, excluding newspapers and brown papers, pieces of straw boards etc.

Chemicals. Lime, caustic soda, washing soda, bleaching powder (if available).

Colours. Methylene blue RX, Congo-red, Chlorazol-yellow, Chlorazol fast blue. (This depends upon the choice of the colour required).

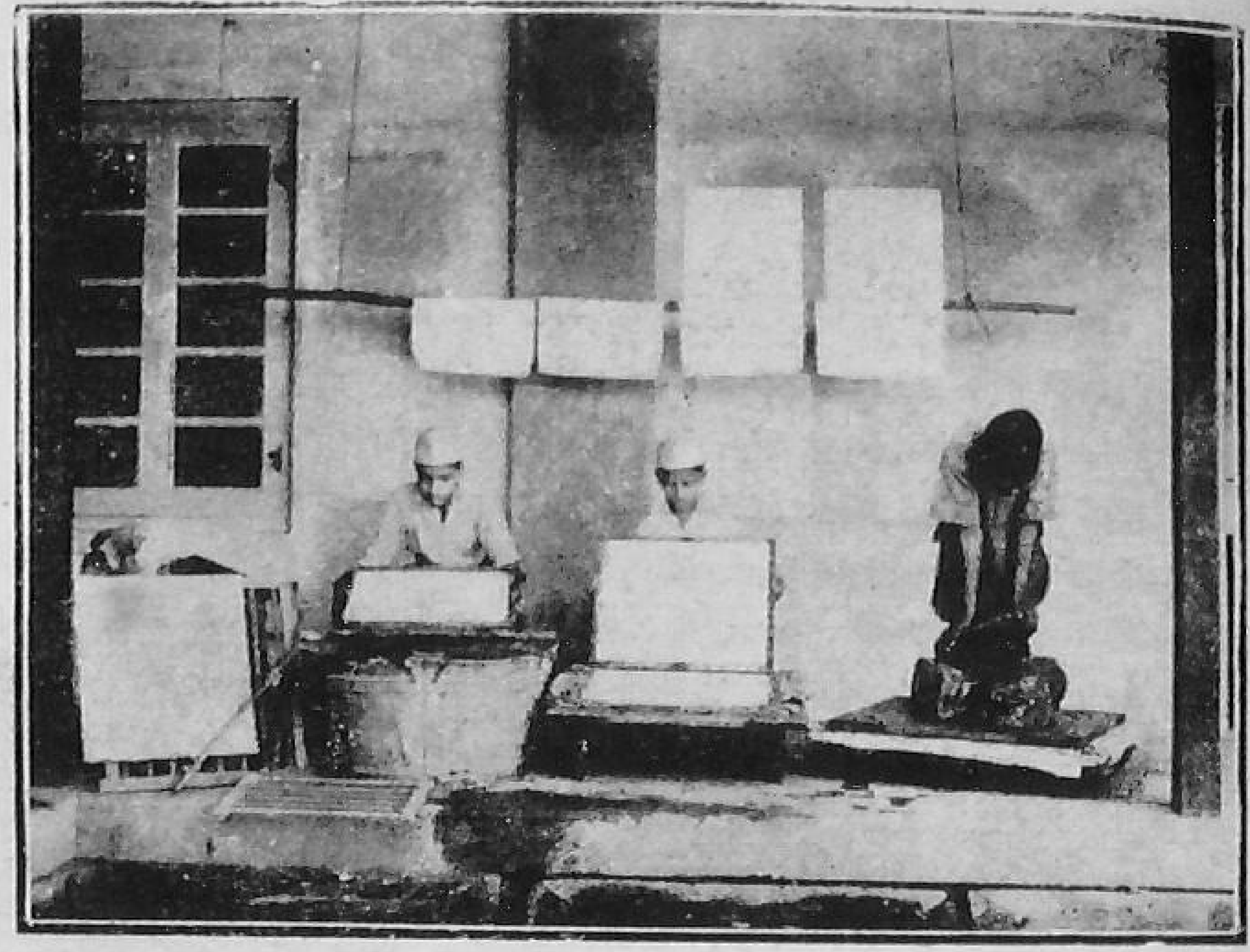
Sizing materials. Wheat or rice starch, rosin and alum. Starch pastes and rosin size can be made as per description in this book. (Chapter IX, Page 11.8)

PROCESSES IN BRIEF

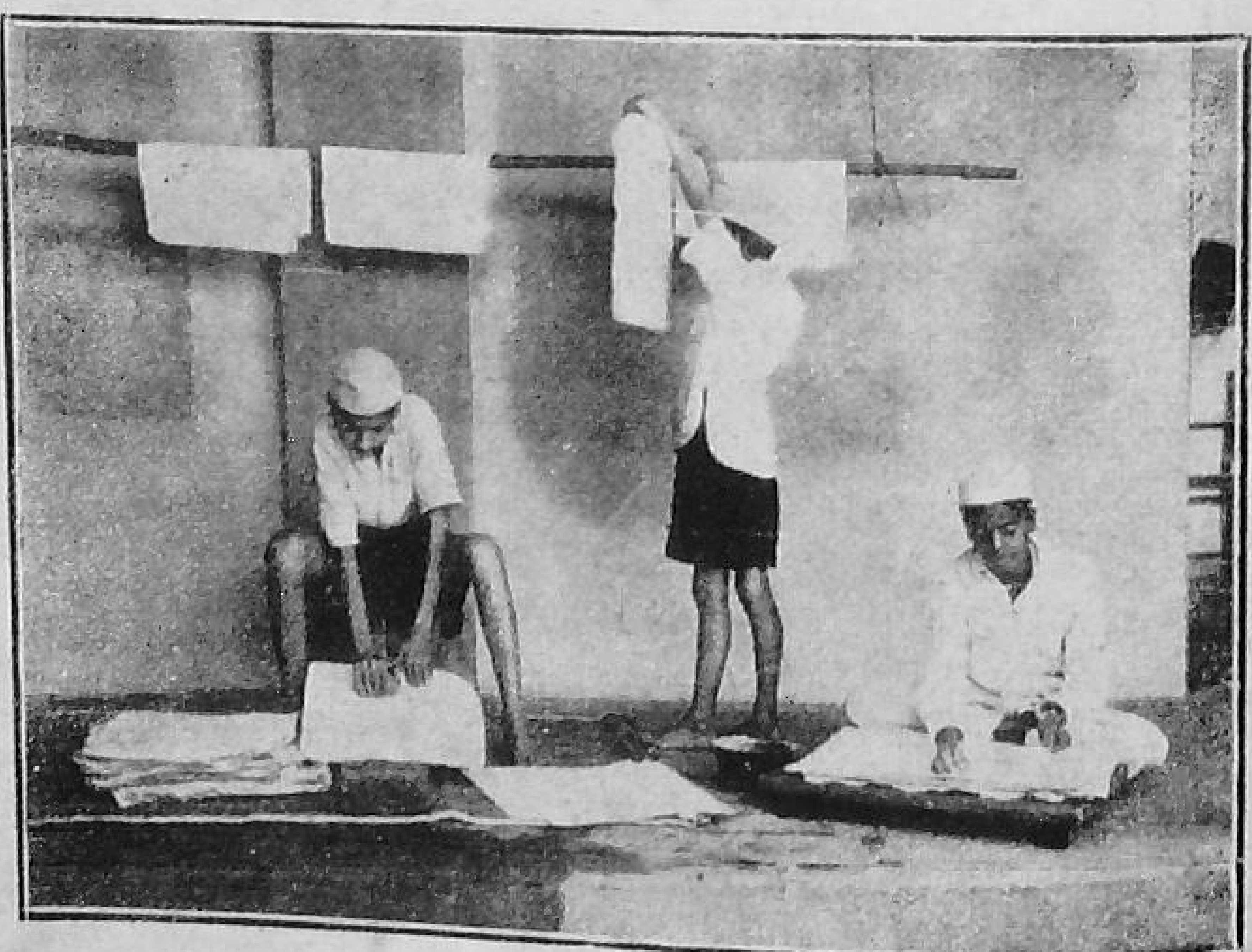
Waste paper such as old answer books, old records, exercise books, letters, printer's paper shavings, etc., should be torn to pieces of about 2″ squares. Then the pieces should be freed from dust by a dusting process and dipped in a sufficient quantity of boiling solution of washing soda or papad-khar or sajji-khar. The quantity of washing soda used should be 4 to 5 per cent of the raw materials. Afterwards the vessel should be taken out of the fire and kept for a day. The waste paper so treated should be trodden under feet in the trampling pits or it should be pounded in a rice pounder or stone pestle and mortar and then rubbed on the rough floor till the paper is reduced to pulp free from all knots and unreduced chits. In case of smaller quantities the paper waste, after treating it with washing soda solution, should be churned with a country churn, mixing it with plenty of water. This does away with the trampling process. The excess water from the churned pulp should be squeezed out through a piece of cloth and finally the pulp may be rubbed on a small chutney stone either by hand or by a stone roller. When

Trampling, boiling waste paper

Churning, rubbing on stone, Rubbing in stone morter
Washing in Bamboo baskets



Grass mat and frame, Paper-lifting, couching, pressing out water paper drying on wall and on bamboo in the rear



Glazing, sizing, drying, sized paper on bamboo in the rear

the pulp is properly made it should be washed in the chudder or in a basket covered with cloth with plenty of water to make it free from soda and other dissolved matters. Then it may be bleached if bleaching is at all necessary or available. In case when tinted or coloured paper is required the pulp should be mixed with a small quantity of the desired colour solution. If the paper is to be sized with rosin, the size calculated at 4 per cent of dry rosin on the weight of the dry pulp, should be mixed thoroughly with the pulp. Afterwards alum to the extent of 6 per cent of the weight of the dry pulp should be added as solution and well mixed with the pulp. Sizing the pulp with rosin is not absolutely essential. The alternative method is to size the dry sheets with starch paste by applying it to the surface either by means of a brush or a piece of cloth.

Since blotting paper is an unsized paper, rosin or starch size should not be given either to the pulp or paper. For coloured blotting papers, Congo-red or pink colour is added to the pulp in the required quantity to get the desired colour.

The pulp either with or without rosin size should be mixed with plenty of water in the paper-lifting tub and the sheets formed one after another on the paper lifting mould and laid on wooden boards. A piece of cloth is placed on each sheet on the couching board. When about 10–20 sheets are piled one over the other, the next process is to remove the water either by pressing the pile in a screw press or book-binder's press or in case no press is available, a wooden board is placed over the pile of paper and sufficient number of stones are put over it so as to squeeze out most of the water. Then the cloth pieces with the sheets are separated and stuck on the walls for drying or they may be detached gently one by one from the cloth and put on bamboo or ropes for drying like clothes. When no rosin size is used then the dried sheets should be sized by applying wheat or rice paste. The starch paste for sizing is made by just bringing starch to boil with 15 times its weight of water and 10% of its weight of alum. The starches are made by soaking rice or wheat for 2 to 3 days in water and by grinding or squeezing out the milky starch.

After drying, the paper is polished with paper weight on the burnisher and then cut into the required sizes. In case envelopes are to be made then the paper is folded and cut with a pair of scissors as per required size of the envelope. Then the envelopes are pasted with gum solution or wheat starch paste.

Paper of the size of small note papers $4\frac{1}{4}'' \times 6\frac{3}{4}''$ or 1/4th fools-cap *i. e.* $8\frac{1}{2}'' \times 6\frac{3}{4}''$ can be made by school children as a hobby even in their houses without any extra equipment whatsoever. For pulp-making bathing stone floor or chutney stone and roller may be used or the pulps can be made in a pot with a wooden churn by mixing the boiled paper with sufficient quantity of water and then rubbed on a chutney stone.

A semi-circular or cylindrical copper vessel similar to that used in the bath room may be used as paper-lifting vat. House-hold dining boards may be used where boards are required for couching and pressing.

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APPENDIX E

MIGRATION OF PAPER FROM CHINA TO INDIA A. D. 105—1500

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Buhler in his *Indian Paleography*[1] published in 1896, makes some remarks about the use of *paper* in India. Some points from these remarks may be noted here :—

(1) Between B. C. 350 and A. D. 1300, a period to which Buhler's work refers, paper was hardly known or at least little used in India.

(2) The introduction of paper is only due to the Muhammadans.

(3) According to Rajendralal Mitra paper was used in Malwa during the 11th century, as proved by a "letter writer," by king Bhoja of Dhara.

(4) The oldest paper MS in Gujarat is dated A. D. 1223-24.

(5) Peterson discovered at Anhilvad Patan paper MSS dated A. D.1327—28 and 1337-38.

(6) Ancient paper MSS from Kashgar were all of them written in Central Asia. They are covered with a layer of gypsum and it is doubtful if they are of Indian origin.

In his book on *Indian Textual Criticism* published in 1941 Dr. S. M. Katre observes[2] : "So far there has not been any consistent or sustained effort at the study of the material of these (*paper*) MSS as it comes down to us from different centres and through different periods." It will thus be seen that there is much scope for a historical study of the introduction of *paper* into India and its increasing use and manufacture from

1. English Trans, Published in *Indian Antiquary*, Vol. XXXIII, 1904 P. 97.
2. Page 8.

indigenous materials on Indian soil. To trace the migration[1] of paper from China to India through different periods of history is a difficult task for a student like myself, not conversant with the first-hand sources of history available in non-Indian languages or literature. I shall, therefore, record in this article only a few references to *paper*, having a bearing on its history with special reference to India, gathered by me during the course of my studies. The credit of the invention of paper goes to a Chinaman Ts'ai Lun, who offered his product to the throne in A. D. 105. A scholar Ts'ui Yuan, who died 37 years after paper was first made wrote to a friend as follows:—

A. D. 105

"I send you the works of the philosopher Hsu in ten scrolls unable to afford a copy on *silk*. I am obliged to send you one on *paper*." Though "The Development of the book in China" has been studied, the development of the book in India remains to be studied and investigated. According to A. W. Hummel[2] the story of the Chinese book seems to have developed step by step from the *wooden* or *bamboo* slip to the *silk* or *paper* scroll, from the scroll to the folded album and from the album to the paged book of modern times.

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1. U. Wayriffe on p. 11 of his *Arabica and Islamica* (London, 1940) makes the following remarks about *paper*:—"About a hundred and twenty years after Muhammed's death...the use by the Arabs of *paper* began about *A. D.* 750, centuries before its use in Europe, and the great growth of Arabic literature began about A. D. 800, though very little paper of our 9th and 10th centuries with Arabic writing upon it has been preserved." These remarks are consistent with the date A. D. 866 of a Muslim paper MS referred to later in this paper.

2. Vide pp. 71-76 of the *Journal of the American Oriental Society* (June 1941). In the article on *paper* in the *Encyclopaedia Britannica* (p. 229 of Vol. 17-14th Edn.) a short history of Paper is given from which I note some important points:—

3. Cf. *Artha-S'asthra* (B. C. 320) of Kautilya, Chap. X of Book II—Procedure of forming *Royal Writs*. The qualifications of a writer (लेखक), the forms of writing and allied matters as laid down in this chapter show the degree of perfection the art of writing had reached in Kautilya's time. This chapter reminds us of Bacon's dictum "Writing maketh an exact man" and it is exactitude, which is the very basis of Kautilya's treatise.

The chronology of this story[3] prior to the invention of paper is not generally known to ordinary readers in India and hence I note it below :—

Incised divination *bones* with inscriptions were discovered in 1899 in Honan Province. They show that books existed at this time (Shang Dynasty). The Chinese pictograph for a "volume" appears on these bones and on early bronzes.

B.C. 13th-14th Centuries

B.C. 1st Century Thousands of inscribed slips were found in the desert sands of Chinese Turkestan.

Seventy eight *wooden* slips, containing an inventory of weapons were discovered by Folke Bergmann of Sven Hedin's Expedition (about 12 years ago) in Central Asia.

A. D. 96

A. D. 105 Invention of paper by a Chinaman Ts'ai Lun as noted above.

According to Sir Aurel Stein[1] the paper invented by Ts'ai Lun in A. D. 105 was made of *old linen rags, fishing nets, bark of trees* and *raw hemp.*

Mr. G. Macartney, special assistant for Chinese affairs at Kashgar discovered 6 sets of MSS known as Macartney MSS. Set VI of these MSS was picked up from the ground at Kuk Gumbaz. Its material is a kind of *soft paper* with a

C. 2nd Century A. D.

(Continued from page 199)

It is supposed that the *art of writing* originated in Egypt. There is an ancient statue of an Egyptian scribe. A photograph of this statue is given by Davies in his *Outline of the History of the World* (p. 22 of 1937 Edition). We can visualize a लेखक or scribe of Kautilya's time writing royal writs on *bhurja* or *palm leaves* in the manner of the Egyptian scribe, who wrote in ink on *papyrus* with a reed pen.

(i) The art of making paper from fibrous matter seems to have been practised by the Chinese at a very distant period. It is traced by some writers to 2nd century B. C.

(ii) In 751 A. D. the Chinese attacked the Arabs in charge of Samarkand. The Arab Governor repelled the attack and captured Chinese prisoners skilled in *paper-making*, who imparted their knowledge to the Arabs. Hence the Arabian manufacture of paper and the large number of Arabic MSS on paper:

(iii) Paper was probably brought into Greece from Asia about the end of eleventh century.

1. Vide his Report on his Explorations in Central Asia and Westernmost China called *Serindin* (Sec. 4., Chap XVIII, pp. 771-7).

darkish colour. According to Hoernle these MSS belong probably to the *2nd century* A. D. Several folios of these MSS have been reproduced in the *Journal of the Asiatic Society of Bengal* (1897).[1]

For students of the history of *rag paper* the discoveries of Sir A. Stein at a watch-station in Central Asia are very important. He discovered some documents on *Rag paper* and Prof. Wiesner analysed them and concluded that the paper of these documents represented a particularly early stage in the evolution of pure *rag paper*. This analysis removes the previous belief, according to which the origin of rag paper is ascribed to an Arab invention first made in Samarkand about the middle of the 8th century A.D. and then spread through the near-East to Europe. The documents discovered by Stein are called Sogdian documents and they are written in early Sogdian language. They were found along with records of the early years of the 1st century A. D. and are not much removed from the Chinese invention of paper in A. D. 105.[2] As these documents were found in parts far away from the Central Asian border province, Stein concludes that the writers of these documents were of a foreign origin and that they adopted Chinese paper for their use very early. Evidently the foreigners adopted the Chinese paper more rapidly than the people of China themselves.

C. 3rd Century A. D.

1. Vide p. 134 of Katre's *Indian Textual Criticism, 1941*.

2. The word *paper* is derived from *Papyrus* (See p. 229 of Ency. Brit. Vol. 17-14th Edition), I am not concerned here with the history of *papyrus*. The use of *papyrus* in ancient Egypt is well illustrated by Egyptian *wall-paintings*. In the *Tomb of Puyemre*. (about 1450 B. C.) there are paintings of *Papyrus harvest*. These pictures show " how the stalks were pulled up in the marshy lakes, tied up into bundles and carried ashore. The beginning of the paper-making is also taking place, for the figure to the right is peeling off the hard exterior coating from one of the stalks " (Vide p. 7 of *Egyptian Wall Paintings* of XVIII and XIX *Dynasties*, Metropolitan, Museum of Art, New York, 1930).

There is a *papyrus* of *2nd century A. D.* containing a greek play with *Kannada* passages. These passages are considered by Grierson as the oldest specimen of Kanarese. The papyrus was discovered in 1897 by the Biblical Archaeological Association at Oxyrhyncus in Lower Egypt and is numbered 413. Dr. Shama Shastri has identified the Kannada Passages. (Vide *Journal of Mythic Society*, Bangalore, 1928—Monograph on this Papyrus by S. Srikantaiya).

According to Stein the paper used for Sogdian documents shows no trace of "Sizing" with starch or
A. D. 312 other gelatinous matter, which is found in later papers found in Chinese Turkestan and which already appears in a *Chinese document of A. D.* 312.

Mr. John C. Fergusson writing in *T'ien Hsia monthly* (May 1940) refers (on p. 434) to a Chinese
A. D. 317 calligraphist Wang Hsi-Chih of A. D. 317. He was supreme in his art, which is decribed by Fergusson as follows :—"His glory was to be able to extract from the *paper* on which he traced with black ink the lines and curves and hooks of his characters such delectable harmonies for the eye of man as no one else can hope to equal."

Rev. F. Weber,[1] Moravian Missionary in Leh in Ladak received some MSS from an Afghan merchant,
C. 500 A. D. who found them in a place near Kuigar, 60 miles south of Yarkhand in the Chinese territory: These MSS are all written on *paper* and form 2 groups, (i) Indian and (ii) Central Asian. The *Indian Group* is written in *North-Western Gupta Characters*, while the other group is written in *Central Asian Nāgarī*. According to Hoernle all of these MSS are *not later than C. A. D. 700.* Hoernle dates them at *about C. 500 A. D.*

Though *paper* was invented in China in A. D. 105 its migration to India appears to have been very
A. D. 671 slow. At any rate it was not as rapid as the early Chinese travellers to India. When the celebrated Chinese traveller I-tsing visited India in the latter part of the 7th century with desire to copy Sanskrit MSS for being taken to China he could not get paper in India and was, therefore, compelled to order some paper from China as will be seen from the following extract from his Record[2] :—

"At the mouth of the river Bhog (j?) as I went on board the ship to send a letter (through the merchant) as a credential to Kwang-Chou (Kwang-tung) in order

1. Vide p. 135 of Katre : *Indian Textual Criticism.*
2. Vide p. XXXIV of Introduction to I-tsing's *Record* (671-695) Trans. by J. Taka Kusu, Oxford, 1896.

to meet (my friends) and ask for *paper and cakes of ink* which are to be used in copying the *sutrās* in the Brahma language (Sanskrit) and also for the means (cost) of hiring scribes."

It is clear from the above extract that *paper* either indigenous or of Chinese manufacture was not available in India in the 7th century, though it was not quite unknown in India at the time as will be seen from the following reference to the use of *paper* found elsewhere[1] in I-tsing's Record :—

"The priests and laymen in India make *Caityas*, or images with earth, or impress the Buddha's image on *silk* or *paper* and worship it with offerings wherever they go."

If Taka Kusu's translation of the original Chinese passage corresponding to the above extract is correct we shall not be wrong in inferring that *paper* was known to Indian priests and laymen in the 7th century A. D. but that it was a rare commodity used perhaps for religious purposes occasionally. Possibly on account of the Chinese contact with India some paper was already introduced into India prior to the visit of I-tsing but its wide-spread use in large quantities or even its manufacture on Indian soil was not given attention to owing to the system of using the *bhurja* and *palm leaves*[2] for writing purposes so common in those days. Speaking of the oral transmission of the *Vedas* I-tsing observes :— (P. 182 of *Record*) "The *Vedas* have been handed down from mouth to mouth not transcribed on *paper* or *leaves*."[3]

1. Vide p. 150 of *Record*. Vide also p. 203, where I-tsing narrates the story of his teacher, who tore all his books and put them into mortar for being used for a statue of *Vajra* then in preparation. His pupils said :—"If it is necessary to use *papers*, let us use blank *papers* instead." The teacher said that he had been led astray by the literature in the mortar.

2. *Hwui Li* in the *Life* of his teacher *Hiuen-Tsiang* who visited India (A. D. 629-645) refers to the Indian use of *palm-leaf* for writing purposes as follows :—

"We come to *(*Kongkanapura*)* ......To the north of the city is a forest of *Talas* trees about 30 *li* in circuit. The leaves of this tree are long and of a shining appearance. The people of these countries use them for writing on and they are highly valued" *(*Vide p. 146 of *Life of Hiuen Tsiang* Trubner, 1911*)*. After the death of Hiuen-Tsiang in A. D. 664, I-tsing started for India in *A. D.* 671 and returned to China in A. D. 693.

3. Cf. Maxmuller's remarks on writing (p. 257 of *Ancient Sanskrit Literature*, Panini office, Allahabad 1912*)*. I note some points from these

It appears from the above evidence that *paper* was not quite unknown in india in the 7th century A. D. but it failed to oust the *bhūrja* and the *palm-leaf*[1] owing to the orthodox tendency of the Indians generally in not adopting foreign things unless compelled to do so by political powers or by dominant cultural contacts, which saturated the Indian life in an overwhelming degree in any given period of history.

A. D. 751

In the history of paper given in the *Encyclopaedia Britannica*[2] we are told that in A. D. 751 Samarkand, then in charge of an Arab Governor was attacked by the Chinese. The Governor repelled the attack of the Chinese and pursued them, making prisoners of some Chinese, who knew the art of making *paper*. These prisoners imparted the art to their Arab masters and in this manner the Arabs began to manufacture *paper*. A large number of Arabic MSS on *paper* is due to this incident. Sir Aurel Stein does not believe in this account as he states that the Sogdian documents on *rag paper* discovered by him, remove the belief so far held about the Arab invention first made at Samarkand in the middle of the 8th century A. D. and then spread through the near-East to Europe.

Before A. D. 851

Sulayman[3] the Arab Geographer refers to the Chinese use of paper for sanitary purposes as follows :— "The Chinese do not clean with water after calls of nature, but wipe with *paper*." If this statement is correct we have to suppose that *paper* was then very cheap in China for being used for sanitary purposes and further that the Chinese were pioneers

(Continued from page 203)

remarks :—(1) *Rigveda* Hymns have been preserved through "unaided efforts of memory," (2) There are references to writing in the *Old Testament* (3) There is no mention of *writing* in Homeric hymns, (4) There is no allusion to writing in the *Brahmana* period (5) *Writing* was possibly introduced towards the latter half of the *Sutra* period.

1. Kautilya in his *Artha-sastra* (c. B. C. 320) mentions in his list of forest products *birch* (भूर्ज) and palm (ताल) yielding leaves (पत्रम्) which the commentary explains as *writing material* (Vide p. 108 of Shama Shastry's Trans. 1929).

2. Vide p. 229 of Vol. 17 of *En. Br.* (14th Edition).

3. Vide p. 98 of S. M. H. Nainar: *Arub Geographers' Knowledge of South India*, Madras University, 1942.

in this custom now common in Europe. Evidently the European use of paper for toilet purposes is no modern scientific invention.

A.D. 866

Mr. G. R. Kaye[1] in his account of the Bakhshali MS states that "the art of *paper* making appears to have been practised by the Chinese at a very early date. From the Chinese the Muslims learnt the process in the 8th century and they *introduced it into Europe and also India about the 12th century.* Among the earliest Muslim *paper* MSS now preserved one was written in A. D. 866, others in A. D. 974, 980, 990 etc. The *earliest Indian paper MSS* were written in A. D. 1231 and 1343. The earlier one measures 6 × 4 inches (ratio 1 : 5) and the other 13½ × 5 inches (ratio 2 : 7)."

A. D. 904-5

In 1938 Messrs. Bernard Quatrich Ltd. of London announced for sale a MS of a "*A Tenth Century Koran*" in *cuffic* characters[2] in 4 volumes, each volume containing a note in Persian showing that the MS was at one time property of a mosque in Persia. The translation of the note as recorded in the catologue is as follows :— "This mosque was repaired by Ahmad b. Abi-al-Qasim al Khaya-quni in the year 292" (=904-5 *A. D.*)- As this MS is written on *vellum* or fine parchment we may not take it into consideration in our history of *paper*.

A. D. 901-995

In 1940 & 1943 Lionel Giles published two articles on *Chinese dated MSS* ranging in dates from A. D. 901 to 996 in the *Bulletin of the School of OrientalStudies*[3] London. These dated documents in the Stein collection show the attention of the Chinese to chronology unlike many of our writers of Brahmanical MSS, which lack in chronology and hence hinder the reconstruction of history on documentary evidence.

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1. Vide p. 9 of *Arch. Surv. of India*, Vol XLIII (1927). The *Bakhshali Manuscript* by G. R. Kaye.

2. *Catalogue* No. 550 (1938) pp. 86-87 Item No. 357 (Koran).

3. Vol X. Part 2 (1940) pp. 317-344 and X Part 1 (1943) pp. 148-171.

Das Gupta[1] makes the following remarks about Chinese *paper currency* in his book on "*Paper Currency in India.*"

A. D. 997–1022

"It was the country Shuh, now the province of Szechhuen, into which a true *paper money was first* introduced......A certain Chang-young brought them into circulation, in order to supply the *iron money* which was two ponderous and inconvenient. These assignats were called *Chetse* or cuts. Under the sign of Chiu-tsung of the Sung (from 997 till 1022) this example was followed and assignats were made under name of *Keaontze* or bills of exchange......Every Keaontze represented one ounce of pure silver."[2]

A. D. 1089–In his *Catalogue of Jammu MSS* (1894) p. 8, M. A. Stein records a paper MS of शतपथ ब्राह्मण dated *A. D.* 1089.

A. D. 1180–Mr. R. A. Sastri[3] in his article "On Old MSS" states that "paper MSS begin with the date 1236 samvatsara *i.e.* 1180 *A. D.*"

A. D. 1223–The oldest dated paper MS in Gujarat referred to by Bühler on p. 97 of his *Indian Paleography* is dated *A. D.* 1223-24.

A. D. 1231–Mr. G. R. Kaye mentions the earliest Indian paper MS written in *A. D.* 1231.

A. D. 1298–Marco Polo refers to the *paper-money* of Tartar Princes.[4]

A. D. 1310–Gough in his *Papers* (p. 24) mentions a paper MS dated *A. D.* 1310. This is a MS of *Bhāgavata* (p. 16).

A. D. 1320–A work on medicine by Vangasena called the *Vaṅgadatta Vaidyaka* is represented by a paper

1. Published 1927, p. 1.

2. Mahammed Taghlak (A. D. 1325-1351) introduced *paper-money* in his dominions, causing confusion and distress to his subjects. He then issued copper-tokens instead of the *paper-notes.* (Vide p. 405 of *History of India* by Elphinstone, 1874).

3. Vide p. 125 of *Bulletin of Ramavarma Research Institute*, Vol. VI, Part II (July, 1938).

4. *Travels* ed. by Thomas Wright, London, 1901, pp. 215-218.

MS in the Govt. MSS Library (No. 352 of 1879-80) at the B. O. R. Institute, Poona. It is dated *saṁvat* 1376=*A. D.* 1320 and is well preserved.

A. D. 1323–The *Avesta Kodex K* 5 reproduced by the University Library, Copenhagen in 1939 was copied on *paper* in *saṁvat* 1379 (17th *November* 1323 *A. D.*) at *Stambhatīrth* or *Khambayāt*.

A. D. 1345–50–Mohammad Taghlakh introduces *paper money* into India.

A. D. 1395–A Marathi document[1] dated *7th December* 1395 uses the term "*Kāgad*" for paper or document. This document hails from Poona District and is a *Vatanpatra* of Govind Honap Deshpande of *Kodhāṇā*.

A. D. 1396–A. MS of *Riṣabhadeva-caritra etc.*[2] containing portions written on palm-leaf and *paper* was copied in samvat 1452—A. D. 1396. It mentions the term *Kagād*.

A. D. 1406–In the account of Bengal by Mahaun[3] the Chinese interpreter to the Chinese embassy that visited Bengal in A. D. 1406. He refers to the *manufacture of paper in Bengal* from the *bark* of a tree. This paper, he says, is smooth and glossy like a deer's skin.

This reference to the manufacture of *paper* in Bengal made by a Chinaman is very important as it has a direct bearing on the history of Indian paper industry. Though

1. Vide शिवचरित्रसाहित्य Khanda 7, B. I. S. Mandal, Poona, 1938, ले. 30 dated *7th December* 1395. (तन्हेकर देशपांडे कैफियत.)

"आम्ही ज्या कर्मास जमान होऊन आपला कागद गोविला"

2. Vide page 82 of *Prasastisamgraha* by A. M. Shah, Ahmedabad, 1937- Colophon: "पोडशक सूत्रवृत्ति तिथ्थोगाली श्री ताडे ।
तथा श्रीरुषभदेवचरित्रं १२ सहस्रं कागदे पंच पुस्तिकां
तपागच्छ नायक श्री देवसुंदरसूरीणामुपदेशेन सं. १४५२.
श्रीपत्तने लेखिता इति भद्रं ॥६ ॥"

3. Vide p. 159 of *Sardesai Comm. Volume* and *JRAS* 1895, 529-533.

paper first makes its appearance in *Indian Paleography* about A. D. 1000 it is difficult to believe that its manufacture in large quantity was commenced by Indians during the first 300 years of its advent. It would be reasonable to suppose that between A. D. 1000 and 1300 the use of paper had not become very much current in India owing possibly to the scarcity of imported paper. It was only when Indians began to manufacture *paper* from indigenous material that it could gradually replace other materials like the *palm-leaf* the *bhūrja*, *parchment cotton-cloth etc.*

C. A. D. 1520

Though *paper* was manufactured in Bengal and elsewhere in India before A. D. 1406 the Mogul Emperor Baber (A. D. 1483-1530) praises *Samarkand paper* in his celebrated Memoirs[1] :—

> "The best *paper* in the world comes from Samarkand. The species of paper called *juaz* comes entirely from Kanegil which is situated on the banks of *Abe-Siah* (Black water) also called the *Abe-Rahmet* (or water of Mercy)."

Evidently Samarkand *paper* had a great history[2] in Baber's time as proved by the belief about the Arab invention of paper in the 8th century A. D., which persists even now in the writings of responsible scholars as we have already seen in this paper.

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1. By Erskine, 1826, p. 52.

2. From a comparison of the chronology of the migration of *paper* to Europe with that for its migration to India it appears that the two migrations have been almost synchronous say between A. D. 950 and 1150. The *Paper* records preserved in India as in Europe date from A.D. 1080 onwards. The history of the transitional stage of this migration needs to be reconstructed with full details, if such a study has not already been attempted by any scholar already.

Davies (in his *Outline of the History of the World*, Oxford, 1937, pp. 285-286) speaks of the contribution of Moslems to the intellectual life of mankind by the *art of manufacturing paper*. "They certainly did not discover this for themselves (they probably learnt it from the Chinese) but they were undoubtedly the means of its introduction into Europe. Before this time books had to be written on *papyrus* or *parchment* but after the Arab conquest of Egypt, Europe was cut off from the *papyrus* supply."

The *Encyclopaedia Britannica*[1] devotes some space to the migration of *paper* to Europe and America, but no attention is paid by the writer of the article to the migration of *paper* to India from China, its far-off home from A. D. 105. My object in giving the foregoing brief but factual outline of the migration of paper from China to India will it is hoped rouse the curiosity of scholars and laymen alike, as we are now passing through a period of paper scarcity to such an extent that at times we entertain the idea of commencing to write our literary productions on the *palm-leaf* and *bhūrja* in the manner of our worthy ancestors, whose continuous endeavour to preserve our ancient learning by recording it on some durable material still excites our admiration and instils in us a spirit of reverence for their methods of transmission and dissemination of literature, which is the glory of mankind in every age and clime.

Prof. H. R. Kapadia in his article on "*Outlines of Palaeography*" published in *Bombay University Journal* (May 1938) p. 105 makes the following remarks about *paper* and its antiquity :—

"Though the preparation of *paper* was known in India as early as 3rd century B. C., it seems that in ancient times Jain works have not been written on it. For, it seems that it was used perhaps for the first time during the rule of Kumarapala and Vastupala as can be seen from Jinamandanagani's Kumarapala-Prabandha (p. 96) and Ratnamandiragani's *Upadesa tarangini* (p. 142)." In footnote 19 on this

1, Vide p. 229 or Vol. 17 of 14*th Edition*. The following facts from this article on *paper* are noteworthy :-

(i) *A. D.* 1102—Oldest document on paper is a deed of King Roger of Sicily.

(ii) *A. D.* 1122 - 1150—First mention of *rag paper* by Peter Abbot of Cluny in his tract.

(iii) *C. A. D.* 1150—Moors in Spain manufacture *paper*.

(iv) A. D. 1231—Frederick II forbade use of paper for public documents.

(v) *A. D.* 1263— the laws of Alphonso *paper* is referred to as *cloth parchment*.

(vi) *A. D.* 1310—Records of the Merton College, Oxford show the purchase of paper.

passage Prof. Kapadia adds :—"From these two references we see that the word *paper* is translated as "कागद" and "कद्गल" (Kadgala). The word "कागद" occurs in Manavijaya's Commentary ('pt. I, p. 167) on his own work *Dharma-Samgraha*. In certain works we come across the corresponding word "कागद"

Though there is some controversy[1] about the origin of the word *China*, which is derived from *Ts'in* dynasty (B.C. 249-220 A. D.) it is doubtful whether *paper* manufacture was "*known in India as early as 3rd century B. C.* as observed by Prof. Kapadia. "The earliest story of Sino-Indian contact is connected with Emperor Hiao-Wu (140-80 B. C.)" and "the starting point of Sino-Indian intercourse is generally put at A. D. 64." If these statements are correct, it is difficult to believe the introduction of the art of *paper* manufacture into India from Chinese sources prior to A D. 105. If it is supposed that paper manufacture in India, prior to the Chinese invention of paper in A. D. 105 was indigenous, we have to point out that no reliable evidence in support of this supposition has been recorded by competent scholars. Under these circumstances we have to believe in the gradual migration of paper from China to India as outlined briefly in this paper from A. D. 105 onwards.

Prof. Kapadia states that *paper* was used "perhaps for the first time during the rule of Kumarapala" who was King of Gujarat from Vikrama samvat 1199 to 1230 (A. D. 1143-1174).[2] This statement is quite in harmony with the data recorded in the present paper.

The Maharastra historian Rajawade[3] makes the following remarks about the introduction of paper into India :—

1. Vide pp. 4-5 *Indian Literature in China and the Far East*, by P. K. Mukherji 1931 (Calcutta)

2. Vide p. 2 of *Life of Hemacandra* (Trans. by Dr. M. Patel) S. J. series Vol. 11, 1936. Jinamandana, the author of *Kumarapala-Caritra* completed this work in A. D. 1435-36. *DharmaSamgraha* of Manavijaya was composed in A. D. 1681 (Vide. p. 594 of Winternitz, *Indian Literature*, Vol. II (Calcutta). No wonder that Manavijaya mentions कागद in his comm. on his own *DharmaSamgraha*.

3. *Aitihasik Prastavana* (B. I. S. Mandal, Poona, 1928), p. 374.

"About 50 or 60 years before 1326 another material for writing on became current. This material is *paper* (Kagad). There are some remote references to the writing on *paper* in the *Jnāneśvarī*."

The *Jnāneśvari*, was composed in A. D. 1290 and as we have already pointed out *paper* MSS of A. D. 1089, 1180, 1223 and 1231 the remarks of Rajawade quoted by me are fully warranted by the dates of these MSS on chronological grounds.

In Marathi work[1] published at Bombay in 1884 a Persian Farman[2] dated A. H. 717 (Śaka 1221)—A. D. 1299 is reproduced (Appendix A) from a copy of it dated A. D. 1705. This *Farmān*, if genuine, must have been written on *paper* but as it is reproduced from a late copy of it dated A. D. 1705, I am not in a position to draw any conclusions from it, even though it was admitted in the court in A. D. 1883 and translated into English by a Moulvi of the Elphinstone High School on 6th October 1883. This *Farmān* is described as a *Dānapatra* from Raja Bimba of Uttara Koṅkana to Purusottampant Kavale.

From Alberuni's "*Notes of the writing of the Hindus*" made *about A. D.* 1030 it appears that the Indians had not then adopted *paper* for writing purposes as will be seen from the following remarks[3] made by him.

(i) "The Hindus are not in the habit of writing on *hides* like the Greeks in ancient times."

(ii) "Muslims too used in the early times of Islam to write on *hides*."

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1. *Sukla Yajurvediya Brahmana* by N. V. Vaidya Purandare, Bombay 1884. The copy of this work in my possession is a copy presented by the author to the late Rao Bahadur Gopalrao Hari Deshmukh, then at Ratlam.

2. Arabic MSS on *Rolls* of paper (about 30 metres long) coming from Moorish States and North Africa have been deposited in manuscript depositories at Barcelona (Spain). They contain diplomatic correspondence between Egypt and Aragon *between* 1300 *and* 1330 *A. D.* The Aragonese letters in this connection are dated *A. D.* 1303, 1305, 1314, 1318, 1322 *and* 1327. (Vide pp. 12-13 of *Egypt and Arogon* by A. S. Atiya, D. M. G. Leipzig 1938).

3. Vide pp. 170-171 of Vol. I of *Alberuni's India* by E. C. Sachau London 1888 (Trubner).

(iii) Alberuni refers to *papyrus* on which the orders of the Khalifs were recorded until shortly before his time (C. A. D. 1030).

(iv) "It was in China proper that *paper* was first manufactured. Chinese prisoners[1] introduced the fabrication of paper into Samarkand and thereupon it was made in various places, so as to meet the existing want."

(v) "The Hindus have in the *South* of their country, a slender tree like the date and cocoa-nut palms, bearing edible fruits and leaves of the length of *one yard* and as broad as three fingers one put beside the other. They call these leaves *tarī* and write on them. They bind a book of these leaves together by a cord on which they are arranged, the cord going through all the leaves by a hole in the middle of each."

(vi) "In *Central* and Northern India people use the bark of *Tūz* tree, one kind of which is used as a cover for bows. It is called *bhūrja*. They take a piece one yard long and as broad as the out-stretched fingers of the hand, or somewhat less, and prepare it in various ways. They oil and polish it so as to make it hard and smooth, and then they write on it. The proper order of the single leaves is marked by numbers. The whole book is wrapped up in a piece of cloth and fastened between two tablets of the same size. Such a book is called *pūthī*. Their letters and whatever else they have to write they write on the bark of the *tūz* tree."

The foregoing minute study by Alberuni of the writing of the Hindus speaks for itself.

Kalhana (A. D. 1148) in his *Rajatarangiṇi*[2] states that a Brahmin Vijayaraja killed an unpopular minister Citraratha) of King Jayasiṁha (A. D. 1128 to 1149). Vijayaraja was killed by royal troops. On his arm was found a *patrika* or leaf with the verse of the *Bhagavadgita*

1. Vide p. 306 of V. Smith, *Early History of India*, Oxford, 1904.
2. Vide Stein's *Rajatarangini*, Vol. II, 174 (Verses 2256-57) Chap. VIII)

(III, 8) "परित्राणाय साधूनां विनाशाय चदुष्कृताम् । धर्मसंस्थापनार्थाय संभवामि युगे युगे ॥ "

Kalhana states that this *patrika*, stating the cause of his action, sanctifies Vijayaraja. Possibly the *patrik* in question was written on the *bhūrja* leaf, which was generally used in Kashmir for writing purposes.

I now close my study of the history of the migration of *paper* from China to India through varied vicissitudes of times and climes between A. D. 105-1500.[1] About six years ago I began to note down facts pertaining to this history and the visit of Mr. K. B. Joshi, the Secretary of the Paper Research Centre, (The All-India Village Industries Association), Poona to the Bhandarkar Oriental Research Institute in May 1943 hastened up my drafting of the present paper on *paper*, in which he is interested both in its technical and historical aspects. I have, therefore, to thank him most cordially for having agreed to the publication of these notes, imperfect as they necessarily are, for the benefit of the general public and scholars alike. The presentation of my data in this paper is, I am conscious, not popular but I feel convinced that I shall be doing wrong to the subject, if I keep hidden the sources of this study from the gaze of the ordinary reader. I hope that my present study will be supplemented by scholars more competent than myself to handle this subject in its varied aspects. Judging, however, by the queries I get about the introduction of paper into India and the absence of reliable material in our Encyclopaedias on the Indian aspect of this question, I have reason to believe, that my present study will clarify this problem to a certain extent,

1. By A. D. 1500 printed books appeared in Europe. The first European printer was Gutenberg of Mainz, who printed "The Indulgence of Nicholas V" in A. D. 1454. Caxton set-up his printing press in England at Westminster in *A. D.* 1477. (Vide p. 388 of Davis : *History of the World* " 1937. As the Chinese were inventors of *paper*, they were also pioneers in the art of *printing* (Vide Carter, Thomas Francis : *The Invention of Printing in China and its spread Westward*, New York 1931). The Earliest datable *block-print* is from Japan and is dated A. D. 770, long before which the Chinese must have practised *block-printing*. The earliest Chinese *printed scroll* is dated May 868 A. D. It is a version of Buddhist *Diamond Sutra*. (Vide p. 568 of *Smithsoniam Report* 1938—Seligman's article on "*The Roman Orient And the Far East*").

as it is put in its chronological perspective, which is absolutely essential for every historical study worth the name. If the introduction of paper into India and Europe has revolutionized modern and mediaeval civilizations, the manufacture of paper by villagers in India will not fail to revolutionize their economics, for the improvement of which The All-India Village Industries Association has been struggling since its inception some years ago. May its heroic efforts be crowned with success, is my only hope and prayer.

ALL INDIA VILLAGE INDUSTRIES ASSOCIATION

MAGANVADI, WARDHA (C. P.)

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	Demy	2	4	0
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	Double Crown	3	8	0
Side pattis spare	Single Foolscap, Double Foolscap or Demy per pair	0	4	0
	Double Crown or Royal per pair	0	5	0
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	Double Foolscap, Demy, Royal or Double Crown per pair	0	5	0
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Pressing Plank Single Foolscap	2½'×2'	3	8	0
Pressing Plank Double Foolscap	2¾'×1¾'	5	0	0
Drying Brush		0	4	0
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Glazing stone	2"×½"	1	4	0
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ERRATTA

Page No.	Para No.	Line No.	Instead of	Read as
1	1	15	Communicating the thoughts	Communicating thoughts
1	3	1,2&3	with the acquisition of the art of writing or depicting the thought pictorially which owes to his faculty of imitation men wrote upon such meterials as bricks or erected pyramids.	with the aquisition of the art of writing or depicting thought pictorially, man draws on his faculty of imitation and wrote upon such materials as bricks or erected pyramids.
1	3	7	Period	Periods
3	3	10	remains in shrouded mystery.	remains shrouded in mystery.
4	3	1	Carried out	carried on
5	2	1	genaraly	generally
6	3	4		(add) Dhulai
7	10	1	stuckon	stuck on
9	3	1	Currency of Bank	Currency or Bank
9	3	18	Christmus	Christmas
17	1	1	As written	As stated
22	1	5	largey	largely
23	3	4	romoval	removal
28	4	7	At I	At fig I
35	1	6	wodden	wooden
36	2	16	than	then
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Page No.	Para No.	Line No.	Instead of	Read as
37	5	4	Characteristics	Characteristic
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44	4	4	insted	instead
46	2	2	siphon	syphon
48	3	1	Wased	Washed
50	2	9	it	in
54	1	20	Strengh	Strength
58	2	2	through	thorough
59	1	4	heights	height
63	3	5	Pulps	pulp
77	4	2	rage	rags
77	4	5	ash bleached	ash and bleached
78	1	4	out	cut
78	3	9	twins	twines
80	4	7	tags	bags
82	2	1	abandance	abundance
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109	2	7	sidas	sides

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114	1	1	te	to
115	2	1	Auorher	another
119	2	2	of	off
120	5	1	gule	glue
120	5	4	it	in
121	1	4	rops	rope
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122	4	3	gelteine	gelatine
124	2	11	$3\frac{1}{2}$	$3\frac{1}{3}$
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214		4	mediaval	medieval

The All-India Village Industries Association

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